METAL INDUSTRY

6 JUNE 1958

Public Relations

BEFORE the war, the term public relations was practically unknown but during it various Government departments found it necessary, in order to get their pronouncements over—and, indeed, in some cases to interpret them—to a wider public than that with which they were ordinarily accustomed to deal, to create appointments in the field of public information. As is natural with Government departments, it was not long before these appointments increased in number, and their holders in status, until at the end the public relations officer became one of the most important figures in the department. Not to be thought lagging in enterprise, some industrial concerns adopted the idea and the P.R.O. became an established fact in many industries—his function being to sell that industry to the press and through them to the public. There is no doubt that in so doing he serves a very useful purpose and that being so it is, perhaps, rather surprising that more organizations do not take advantage of the possibilities which lie open in this sphere.

Indeed we can think of many in the non-ferrous metal industry who would benefit by following such a course. Consider, for instance, the London Metal Exchange. It is very doubtful whether a more misunderstood, and consequently maligned, body exists. Even in trade circles, where many manufacturers would favour price control such as existed during and just after the war, the functions of this body, which after all controls the price of the basic materials on which the very existence of the non-ferrous metals industry exists, are not clearly understood. How many times, for instance, do we hear that dealing in non-ferrous futures is a form of gambling, carefully to be avoided by all sober-minded individuals? Or that price fluctuations are engineered by the members of the Exchange for their own benefit? It is true that articles on the functions of the Exchange have been published—indeed, we ourselves have done so—and that lectures have been given by prominent members in various parts of the country; but we feel that it is essential in the interests of the L.M.E. that the true facts should be brought home to the general public as well as to those directly interested.

Another field in which similar considerations apply is the copper industry. Erratic price fluctuations and uncertainty as to the future have affected the industry adversely. Public relations are needed to bring home the truth that copper resources are abundant, that smelting and fabricating facilities are adequate for any foreseen eventuality and that there are distinct possibilities that a more stable price can be achieved. The general public should be made aware that for certain purposes copper is irreplaceable and its virtues should be extolled in every possible way. Even with the light metals where enlightened publicity has created extensive markets in a comparatively short time, increased usage can only be assured and present markets retained by constant inter-awareness between producer and consumer—the producer must know minutely the potentialities of prospective markets and the consumer must be cognizant of the specific qualities of an alloy in any given application.

These considerations all point to more effective public relations. Too often this aspect of publicity is overlooked or neglected. On every hand there are examples of products that are in no way better than competitive goods but which reach tremendous marketing figures as a result of efficient publicity. Wherever there is any suggestion of a lack of understanding between an organization and the public—and even where there is no such suggestion—effective public relations can remove the barrier. The operative word, however, is effective.

Out of the
MELTING POT

Extension

AS might have been expected, it could not be very long before nickel ceased to be the only metal that could be deposited by the so-called electroless plating process from a hypophosphite bath. Indeed, the possibility of depositing cobalt and chromium by this process had been mentioned before, although this possibility had not so far been carried to its practical conclusion, presumably because of lack of demand in the case of cobalt, and technical difficulties and/or unfavourable economics as compared with conventional electroplating in the case of chromium. This did not mean, however, that behind the scenes work was not being done on the electroless deposition of metals other than nickel. Some results of this work have recently been claimed in a number of U.S. Patent Specifications. The first of these claims a process for the electroless deposition of iron from a bath containing 30 gm/L. of ferrous sulphate, 10 gm/L. of sodium hypophosphite and, in addition, 25-100 gm/L. of a buffering and sequestering agent such as oxalic acid and its salts, citric acid and its salts, and Rochelle salt. Apart from buffering the bath in the basic region (*p*H 8-10), the sequestering agent forms complex compounds with the ferrous ions and thereby prevents the formation of ferrous hydroxide. The bath is used at a temperature of 75-90°C. Another patent claims the use of hypophosphite baths containing one of the above organic buffering and sequestering additives to deposit alloys of iron with nickel, cobalt, or chromium. The examples described include the deposition of 50-50 iron-nickel, 70-50 iron-cobalt, and 90-10 iron chromium alloy coatings. A further patent extends the claims to the electroless deposition from such baths of vanadium-containing coatings, the vanadium being added to the bath in the form of sodium vanadate. Coatings containing, for example, 80 per cent chromium and 20 per cent vanadium, 84 per cent iron and 16 per cent vanadium, 85 per cent nickel and 15 per cent vanadium, and 90 per cent cobalt and 10 per cent vanadium have been obtained. It is interesting to note that no mention is made of the presence in these coatings of phosphorus, the presence of which is such a characteristic feature of the electroless nickel coatings. Attempts to deposit vanadium on its own were unsuccessful, its activity is so high that it will oxidize before deposition occurs, and only vanadium oxide is obtained.

No Longer

ONE of the risks that must be faced when complaining about what appears to be, to all intents and purposes, an irreversible trend, is the possibility that, imperceptibly, such a trend may, in fact, become less pronounced or may even become reversed. Fortunately, though such a risk is always present, its consequences are not serious: little harm is done by inveighing against a waning or, ultimately, non-existent trend. One such trend is undoubtedly the trend towards greater and greater specialization. Its existence was first inferred—quite a long time ago—when somebody noted, and promptly deplored, the fact that more and more scientists could no longer hold converse in Latin or in ancient Greek, were not acquainted with classical mythology and literature, and, worse still, if they happened to be concerned with, say, metallurgy, might well never even have heard of, say, plant morphology. Once this trend towards specialization was detected, its continued progress (knowing more and more about less and less) was taken for granted, and anybody so inclined set about deploring it and its consequences, and suggesting ways and means of counteracting them. All this did not remain entirely fruitless. To-day, an unbiased examination of the situation using reasonable criteria, which would exclude, for example, the necessity of an intimate knowledge of the classics, would lead to the conclusion that the trend had reached one of those nowadays so popular plateaux, or had even started on a gradual descent towards just a little less about just a little more. While complaints about the decline of specialization would, perhaps, be as yet premature, complaints about its continuing growth and its unfortunate consequences could now certainly be abated.

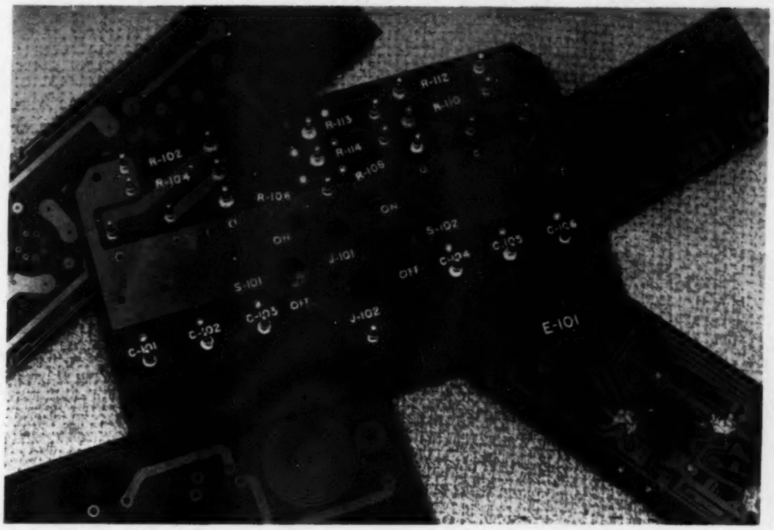
Some Progress

WHEN, a few years ago, publication of the patents, and of a few Papers and articles, brought the news of the work on magnesium alloy extrusions made from atomized powder instead of the conventional cast billets, one was left with the impression of yet another exercise in more or less theoretical powder metallurgy, or yet another of those processes too good to come true in the imperfect world of industrial production. Now, after several years, theory has nevertheless been reduced to practice, and magnesium alloy extrusions—referred to as pellet extrusions—are, in fact, being produced from powder; sorry, pellets. The latter, which average 0·016 in. in diameter, are made by running a stream of molten alloy on to a disc spinning in an atmosphere of neutral gas. The solidified droplets are blown to a screening section, where over-size pellets are removed. The pelletized material is moved pneumatically, preheated, and then blown through pipes into the container of an ordinary extrusion press, from which it is then extruded. The main reason for using pellets instead of cast billets is that the extrusions produced have a finer grain size and, therefore, better mechanical properties, particularly compressive proof stress. The grain size of the pellet extrusions, unlike that of conventional extrusions, is less dependent on the amount of work put into the metal during extrusions, i.e. on the extrusion ratio, since there is no need for a thorough breaking down of the cast billet structure. This is reflected in the mechanical properties of the extrusions, which do not decrease as the cross-section of the extrusion increases, and also in the uniformity of the properties in different parts of an extrusion comprising thin and thick sections. The chief remaining drawback so far as pellet extrusions are concerned is that their price is some 50 per cent above that of ordinary magnesium alloy extrusions. The established billet-casting and extruding procedure still manages, it seems, to score over the potentially cheaper method with its efficiency and ease of moving the pellets automatically, and its possibility of being developed into a continuous extrusion process with none of the pitfalls that beset such a process (e.g. in the extrusion of aluminium cable sheaths) when cast billets are used.

Skimmer

Printed Circuits

By ANDRÉ ROOS



One of the main factors in the rapid development of electronic equipment has been the use of printed circuits which enable accurate and robust instruments, occupying a minimum of space, to be manufactured. In this article, an abridged translation from "Cuivre, Laitons, Alliages," a description is given of the production of the copper-plastics laminates on which the required circuits and components are subsequently printed.

DEVELOPMENTS in electronics and the tremendous expansion in the use of electronic equipment have rendered it imperative to improve on the manual method of wiring circuits with soldered joints made one by one with the aid of a soldering iron. This cumbersome procedure has been eliminated by the use of the printed circuit—a panel upon the surface of which is imposed a predetermined pattern of the required circuits. This does away with the intricate work of cutting wires to length, positioning them, assembling them, soldering all the connections by hand, and finally testing each part of the circuit.

A printed circuit consists of a sheet of plastics material covered by bonded-on sheets of rolled copper of a suitable thickness and having suitably chosen properties. An impression process is used to form the copper circuit on the plastics insulating support. The process starts by the bonding of a sheet of copper to the plastics support, this being followed by the etching away with acid of the portions of the copper sheet that do not form the actual network of the desired circuit. The metal left behind constitutes the electrical conductors of the circuit. It is worth recalling the basic principle which renders this type of circuit particularly advantageous: the heat generated by the passage of an electric current is more effectively dissipated from a flat than from a circular conductor, since, for one and the same cross-section, the flat conductor has a larger periphery than the circular conductor. That is so in the case of the printed circuits. Moreover, the characteristics of the dielectric circuit have an additional beneficial effect on the dissipation of the heat, and it is therefore possible to increase considerably the limiting current densities. Thus with 25 amp/mm^2, no rise in temperature is noticeable. With 40-50 amp/mm^2, the temperature rise is only 15°C., and it is only with a current density of 125 amp/mm^2 that the heat generated in the conductors results in a detachment of the copper from the plastics support.

Another important advantage is that owing to the choice of the insulating support it is possible to achieve excellent mechanical and electrical characteristics adapted to the particular application. Thus, depending on the choice of the insulating material, the printed circuits can be arranged to have a very low moisture absorptive capacity, to resist high tensile stresses, to show a satisfactory behaviour at elevated temperatures, to resist arcing, and to have very low dielectric losses.

Finally, it must be emphasized that the manufacture of printed circuits is particularly well adapted to mass production at low cost, and that labour costs for assembly are very much reduced, it being possible to make a large number of connections in a few seconds by the immersion soldering technique in a tin solder bath. Once manufactured, printed circuits can be easily stored and transported, which leads to the possibility of maximum decentralization of the assembly lines.

Principle of Manufacture

More than twenty-five methods have been devised. Among these may be mentioned the method of printing on a ceramic surface with metallic inks which are caused to fuse at high temperature to form the conductors of the circuit; spraying of molten metal on the insulating support through a stencil; the stamping of a metal sheet which is subsequently bonded to the plastics sheet; press bonding at elevated temperature of a metal network to a plastics sheet; the printing of the circuit on glass with a silver salt base ink, the silver salt subsequently being decomposed to precipitate silver which constitutes the circuit. The process to be described here is that patented by Dr. Paul Eisler. This British citizen, of Austrian origin, conceived this process during the war, in collaboration with Harold Strong, the owner of a printing works.

Having offered their process to various manufacturers, these two inventors had no success until, in 1947, to their great surprise, the U.S. Bureau of Standards published its report on the manufacture of the so-called proximity fuses for anti-aircraft shells. Millions of these fuses had been manufactured with the incorporation of printed circuits. Other, more peaceable, uses soon followed. Today, this process is by far the most widely used.

The support consists of a sheet of plastics material which is clad with copper. It is on the surface of the copper that the circuit is printed. The first stage of the process consists of drawing the plan of the circuit on a large scale. A negative photograph of this plan is then taken for the purpose of reproducing the pattern on the surface of the copper sheet. This pattern must be formed using an etch-resistant nylon-base coating which is applied by the photogravure or offset process. The panel coated in this way is then immersed in a chemical etching bath so as to etch the portions of the copper surface not printed over by the nylon-base coating. After the etching, the panel is rinsed and dried. It is then ready for the subsequent manufacturing and assembly operations.

Choice of Plastics Material

Thermohardening plastics, used in the form of sheets, are manufactured in the U.S.A. by various producers.

Phenobite-base epoxy resin compositions are used for the laminates

manufactured by the National Vulcanized Fibre Co. Their special characteristics are resistance to moisture, which they do not absorb, their resistance to elevated temperatures, and their low dielectric losses. If breakdown due to sparking or arcing is liable to occur, this company also manufactures a material based on melamine and silicone resins. The Formica Co., specializes in grades of plastics which, in addition to the above properties, are also easy to form, bend and draw. Apart from the melamine and silicone compositions, this company also produces a nylon-base composition, having high insulating properties and other excellent mechanical and electrical characteristics. The laminates produced by the Synthane Corporation are capable of withstanding 218°C. for 10 sec., which makes immersion soldering possible. The products supplied by this company meet the requirements of mass production: ease of sawing, moulding and drawing. Other manufacturers use "Teflon" for the purpose of obtaining resistance to elevated temperatures. In general, the properties demanded from the plastics material are the following: (1) Adequate mechanical strength to permit the operations mentioned above (sawing, etc.). (2) Resistance to attack by the chemical etching reagents used to etch the copper cladding. (3) Resistance to elevated temperatures. (4) Resistance to moisture. (5) Suitable electrical resistivity and dielectric properties.

The plastics base materials are usually manufactured by the following procedure. Use is made of a special cellulose paper which is impregnated with a thermohardening synthetic resin. A certain number of layers of the impregnated material are laminated under heat and pressure. The chemical reactions which take place, transform this assembly into a dense solid having a certain hardness and plasticity. The process makes it possible to obtain mechanical and electrical properties suited to the particular purpose in mind.

Copper Sheet

The copper sheet which is to be bonded to the plastics base is produced in the U.S.A. by a special electrolytic process. This process enables the production of a refined high-purity copper having a porous surface which will readily adhere to the plastics. The production is carried out in vats containing large lead drums, 6 ft. in diameter and 4 ft. 6 in. wide, arranged horizontally. It is on these drums, acting as cathodes, that the copper is deposited, the anodes being arranged on the bottom of the vats which are filled with electrolyte. Only the lower portion of each drum is immersed in the liquid. The drum rotates slowly about its horizontal axis at a constant speed. As the drum rotates, copper is deposited on the immersed portion of the surface of the drum, deposition being halted as the surface of the drum rises above the surface of the electrolyte. The sheet produced in this way is rinsed, dried and detached from the surface of the drum, and is then coiled mechanically. The process is a continuous one. For a given current density, the thickness of the copper sheet obtained, is determined by the speed of rotation of the lead drum. An electrolysis plant for the production of copper sheet at the Raritan Copper Works of the International Smelting and Refining Company, a subsidiary of the Anaconda Copper Mining Company, at Perth Amboy (N.J.), U.S.A. is shown in Fig. 1. It may be mentioned that, apart from its use in the manufacture of printed circuits, the copper sheet is used in the building industry, in particular for the damp-proof course in walls.

The main properties of the copper base material are listed in Table I.

Manufacturing Process

Various metals have been used for printed circuits: aluminium, brass, and silver, in particular. Copper alone has, however, proved really satisfactory, as it possesses the necessary strength, the electrical conductivity and a reasonable price. The thin electrolytic copper sheets have a thickness of about 0·035 mm., and thicknesses of up to 0·070 mm. can be used. The sheets are bonded under pressure to the plastics panels. The adhesive used should give a strong adherent bond capable of resisting acids and elevated temperatures. The electrolytic copper sheet is used because of its slightly rough non-greasy surface which is easy to bond.

The copper-clad plastics panels are then cut to the required size for the manufacture of a large number of printed circuits. It is sometimes possible to manufacture as many as fifty circuits from one panel. After cutting, the plates are washed by immersion in a cyanide solution, and then scrubbed and washed in cold water. Their surface appearance is

TABLE I—CHARACTERISTICS OF COPPER SHEETS FOR PRINTED CIRCUITS ON A FORMICA BASE

(According to the Formica Co., Cincinnati, Ohio, U.S.A.)

Sizes of Sheets: 915 mm. × 1,060 mm., 915 mm. × 1,420 mm., 915 mm. × 1,520 mm., 915 mm. × 1,830 mm., 915 mm. × 2,440 mm.

Thicknesses of Sheets: 0·035 mm., 0·07 mm., 0·015 mm. depending on requirements

Bending Characteristics	**Type I**	**Type II**	**Type III**	**Type IV**
Use a copper thickness of 0·07 mm. in order to be sure of a sufficient resistance to bending. For very small bending radii, panels copper-clad on both sides are preferable in order to avoid distortion.	Sheet clad on both sides; copper removed from both sides of bent portion.	Sheet clad with copper on one side; copper cladding on interior of bend.	Sheet clad with copper on one side; copper cladding on outside of bend.	Sheet clad with copper on both sides; bent portion clad with copper on both sides.
Thickness of plastics-copper laminate in mm.	0·8 1·58 2·4 3·2 4·76 6·35 7·93 9·5	1·2 1·58 2·4 3·2	1·2 1·58 2·4 3·2	1·58
Minimum bending radii in mm.	0·8 2·4 4·76 9·7 15·9 25·4 31·7 63·5	7·9 9·5 15·9 25·4	14·3 17·5 38·1 50·8	41·3

Fig. 1—Plant for the electrolytic production of copper sheet for printed circuits

carefully examined (Fig. 2). The copper surface is then coated with a photosensitive emulsion by spraying. This is dried quickly (2 to 3 min.). The emulsion used is only sensitive to strongly actinic light (electric arc) and can be handled in ordinary light without special precautions.

It should be noted that the perfect adherence of the metal sheet on the laminated plastics panel, determines the life of the printed circuit. This adherence is required not only during normal service of the panel but also during soldering, especially if the latter has to be done by immersion. The bonding is effected either by using a film of adhesive, or by varnishing of the copper. Fig. 3 shows the loading of the laminates into the bonding press.

The next operation is the preparation of the plan of the circuit. This is drawn to a scale 3 to 4 times the size of the required printed circuit and is then photographed to obtain a negative having the actual size of the circuit which is then contact printed onto the copper surface. Care has to be taken to ensure a close contact between the photosensitized copper surface and the photographic negative of the circuit. This is achieved by placing the two in an airtight frame under vacuum. In this way an intimate contact is obtained during the exposure to an arc light. The duration of the exposure varies, depending on the sensitivity of the emulsion, between 45 sec. and 6 min. After this exposure the panel is immersed in a bath of photographic developer. The chemicals of the developer result in the solution of the non-exposed portions of the photosensitive emulsion and the fixing of the exposed portions. The surface of the panel is thus left carrying a pattern which is resistant to the action of acid and which faithfully reproduces the pattern of the circuit.

After washing and examination the panel is then ready for etching.

Etching is done in an acid solution of ferric chloride of 40°Bé. This solution attacks all the portions that are not covered with the acid-resistant varnish. The etching takes from 2 to 20 min., depending on the equipment used and the thickness of the copper sheet. In certain types of equipment the solution is sprayed on the surface. This is a rapid method of etching, but its output is limited by the fact that only a small number of panels can be treated at one and the same time. For mass production, the panels are carried by a conveyor into an etching bath of suitable size and suitably equipped in order to permit a relatively rapid etch (10 to 20 min.). In order to ensure uniformity, the etching process must be carefully controlled. In particular it is necessary to maintain a constant concentration of the etching solution, as well as a constant temperature and speed in order to avoid excessive or insufficient attack.

Fig. 2—Examination of the copper-clad plastics panels

The etched panels are then cleaned before subjecting them to a treatment intended to neutralize the residual etching solution, and then to a second treatment the purpose of which is to protect the surface against oxidation on the one hand, and to prevent wear of the copper on the other. Where sliding contacts are involved, this second treatment consists in the deposition of nickel, silver or rhodium for the purpose of improving the surface from the point of view of electrical contact or hardness. The panel is then punched to shape using suitable tools. Bakelized paper is punched at elevated temperature (between 120 and 140°C.) up to thicknesses of 2·5 mm., and the plastics laminated materials are punched cold up to thicknesses of 3 mm.

Mounting varies depending on the type of circuit. The various units (resistors, capacitors, valves) are connected by the conductors of the printed circuit. These connections are effected either during the actual manufacture of the circuit, the resistors and capacitors being formed by elements of the

Fig. 3—Loading of the copper sheets and of the plastic panels into the press for bonding

circuit, or by soldering when it is necessary to connect the resistors and capacitors, the soldering being effected either joint by joint or by immersion after application, with a brush or by a spray gun, of a film of an alcoholic solution of resin flux.

After all the elements of the circuit have been connected up on one side, the dielectric base is pierced by accurate holes. It is this side that is immersed in the soldering bath (60 per cent tin—40 per cent lead solder) at a temperature of about 210°C. for 4 to 5 sec. Immediately afterwards all the projecting portions are cut. In this way it is possible to make a large number of soldered joints, this being one of the chief advantages of this new technique.

The circuit is then ready for use (see illustration at the head of this article).

In electronic computers certain parts of the wiring which require several hundred yards of insulated round conductors are now replaced by printed circuit units constituting readily accessible sub-assemblies.

Various control units, resistors of electro-medical apparatus, cinema projectors, radio transmitters and receivers, and radiosondes can be greatly simplified, rendered more accessible, more reliable, more robust, less bulky and lighter when they are manufactured using the printed circuit technique by means of which several yards of flat conductors can be obtained in a very small volume.

Certain sliding contacts and certain discs carrying numerous contacts can be made by the printed circuit method, the resistance of the conductors being increased by plating them with rhodium.

The latest application of the printed circuit technique is in the manufacture of small transformers. In these, the numerous turns of wire of uniform cross-section of considerable weight and subject to heating up are replaced by windings on thin, strong and insulating plastics material. These windings are then folded accordion-fashion, and, after the stamping out of the central portion to permit insertion of the magnetic core, one obtains transformer windings which are very light, occupy very little space and ensure a satisfactory temperature distribution by increasing the cooling surface of the interior windings.

Transistors, semiconductors based on germanium, have recently brought new progress into the design of electronic equipment. With these crystals, detection and amplification are performed in a very small space with a very high output. These minute units are characterized by their strength, their simplicity, the ease with which they can be mounted, their low energy consumption, and their modest production cost. It is essential in designs of electronic equipment not to submerge the transistors under a mass of wiring, joints and resistors: hence the usefulness and the necessity of using printed circuits.

Men and Metals

It has been announced by The British Aluminium Company Limited that **Mr. J. W. Bennett,** lately President of Atomic Energy of Canada Limited, has been appointed general manager of the Canadian British Aluminium Company Limited, in succession to **Mr. P. T. Ensor,** M.B.E., who is returning to the United Kingdom in July to take up other duties with The British Aluminium Company Limited.

Head of the Copper and Copper Alloy Section of the Research Department of I.C.I. Ltd. (Metals Division), Witton, Birmingham, **Mr. W. H. L. Hooper,** B.Sc., A.I.M., has been

seconded for a three-year period to I.C.I. (New York) Ltd. Mr. Hooper, who has been with I.C.I. Ltd. (Metals Division) since 1946, will act as technical liaison representative in succession to **Dr. W. O. Alexander,** who is returning to this country.

We are informed by Technical Designs Limited that they have appointed **Mr. P. B. Ward** as sales manager of the organization. Prior to this appointment, Mr. Ward was sales manager of Danite Hard Metals Limited, and previously with Deloro Stellite Limited.

Following the retirement of **Mr. M. H. Healey** as branch manager of the Nottingham office of British Insulated Callender's Cables Limited, **Mr. J. Floweth** has been appointed to that position. Mr. Floweth joined the company in 1927, and in November, 1948, was transferred to the home sales department at the Nottingham branch.

We are informed that **Mr. T. W. Ruffle,** F.I.M., has left the E.N.V. Engineering Company Limited and, after some weeks in the U.S.A., he will be setting up a British office for Ipsen Industries Inc., of Rockford, Illinois. This will establish sales and service facilities here for the Ipsen automatic atmosphere heat-treatment furnaces and accessories, atmosphere generators, and atmosphere control instruments, which are now available on the European market.

In charge of the North Western European Department of the Overseas Division, Expandite Limited, **Mr. J. A. Orbell** is leaving for a tour of Holland and Germany. During his tour he will study the possibilities of manufacturing certain of his company's materials locally.

INFORMAL DISCUSSION ON PRACTICE OF COMPACTING AND SINTERING

Developments in Powder Metallurgy

AN informal discussion on "Developments in the Practice of Compacting and Sintering," organized by the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals, was held recently at Church House, Westminster, London, S.W.1.

At the morning session **Dr. Ivor Jenkins,** F.I.M., Chairman of the Joint Group, took the chair, and after lunch the chairman was **Mr. D. A. Oliver,** Deputy Chairman of the Joint Group.

The following Papers were presented and jointly discussed at the morning session.

"Compacting of Powders using Moulds made from Reversible Gels," by **T. W. Penrice** (Production Tool Alloy Co., Ltd., Sharpenhoe, Bedford).

"The Continuous Production of Strip by the Direct Rolling Process," by **D. K. Worn** (The Mond Nickel Co., Ltd., Development and Research Department, Birmingham).

"The Consolidation of Metal Powders by Hot Working within Sheaths," by **J. Williams** (Atomic Energy Research Establishment, Harwell).

DISCUSSION

Dr. W. D. Jones (Powder Metallurgy, Ltd.):

Already a number of the rarer metals are handled by powder metallurgy, and there are signs that copper, nickel and cobalt may be both extracted and fashioned by powder techniques.

Dealing first with Worn's Paper, this may indicate that progress in Britain is perhaps in advance of that in other countries, or at least this Paper may stimulate other countries to announce their position. If it is going to be necessary for us to handle metal powders in future by rolling processes, we shall have to know a great deal more about the mechanics and physics of powder rolling. There ought to be more Papers in which the detailed physics of the powder process is examined during the rolling, and more data given of the type of those given by Worn on such questions as strip density, powder characteristics and so on. No one appears to have studied as yet precisely what happens to a particle when it goes through a roll gap.

It seems that, from the economic point of view, powder rolling may be restricted by the fact that it cannot be done fast enough. The rates of rolling which Worn has indicated are very slow compared with those of rolling solid metals. There seem to be two obstacles. One is the rate at which powder can be fed into the roll, which is presumably connected partly with the rate at which it is possible to eliminate the gaps but also with the rate at which the powder itself will flow. Has anyone given any thought to the possibility of forcibly feeding powder into the rolls by some sort of slinging technique, as with a sand slinger?

Worn has referred to very high rates of sintering, but, if much higher powder rolling speeds are to be obtained, there will be difficulty in sintering fast enough without the use of impossibly long sintering furnaces. Is it possible to coil a powder rolled strip in the green state and subsequently batch sinter it in the coil condition?

Surprisingly little has been published about manipulating inside the sheath. It seems that this must be an expensive process; in fact, Williams has already said so. In some cases might it not be cheaper to extrude or roll the product in a gas-filled room. In America there is a plant in which molybdenum is hot rolled in a room filled with helium, the operatives wearing suitable gas masks. Has anything like that been proposed in Britain in this field?

Penrice appears to deal with an elegant method of pressing individual objects not direct or continuous powder metallurgy. It would not be surprising if the technique became widely used in various parts of the world. As the author points out, the disadvantage of pressing in the die is frictional loss. On the other hand, the advantage of pressing in the die is that it can be done very quickly. Automatic presses can turn out pressings at an extraordinarily high speed. Has the author considered how it would be possible to mechanize his Vinamold pressing technique? In America one sparking plug manufacturer has a type of hydrostatic pressing which is mechanized.

W. H. L. Hooper (I.C.I. Ltd., Metals Division):

At I.C.I. in work on titanium the question of impurities has given trouble. Do they get into the powder accidentally or are they incorporated in it. There is an oxide film on the surface of the particles. Can Worn say anything about the effects, in his experience, of oxide films on powders?

Dr. R. Edwards (Metro-Cutanit Ltd.):

Has not Penrice been a little misleading in suggesting that pressures of the order of 2 tons/in^2 are about the maximum used on hydrostatic presses. There are many hydrostatic presses operating in this country at above this pressure; 5 tons/in^2 is fairly regularly used, and some organizations use pressures as high as 10 tons/in^2. It would appear from the Paper that there was some disadvantage in hydrostatic pressing compared with the reversible gel mechanism which limited the pressure to the order of 2 tons/in^2. With the reversible gel method are not the pressures transmitted to the wall of the mould almost identical with those which would occur using water?

This method of pressing shows an advantage when large bars have to be pressed. For very small articles the automatic pressing technique cannot be superseded, but on large bar pressings there is a tendency, as a result of poor powder fill, for a pressing to come out with rather a wavy surface, due to the fact that it is impossible to pack evenly. What is Worn's experience on this point, and has he had to resort to machining after pressing?

He mentions that at pressures of 10 tons/in^2, shrinkages were comparatively low compared with 2 tons/in^2, but at 5 tons/in^2 with cemented carbide, shrinkages are of the order of 19-20 per cent. With this method of pressing the great disadvantage of expansion of the pressing after it has been pressed is overcome.

J. E. Elliott (Bound Brook Bearings, Ltd.):

Penrice appears to be moving nearer to an analogy with an ordinary moulding and casting process, because he has taken virtually a semi-pendant mould, he is using a pattern, and, instead of casting metal into that mould, he fills it with powder and sinters, so that there is a nearer analogy between an ordinary casting technique and powder metallurgy than we have when using the ordinary compacting process.

To carry this analogy a stage further, take the case of a material such as cast iron. Cast iron is a class of material of which it may be said that the sintered material, a sintered copper alloy, has similar properties. It is also a low ductility material and has the appropriate strength. It is not often that a porous material has properties equal to those of a solid material, but in this case it approximately equals cast iron. At the moment, for very simple shapes in this class of material, a powder metallurgy product is probably cheaper and capable of greater dimensional precision than a cast iron article. For more complex sections cast iron comes into its own, and using ordinary compacting techniques there is a distinct limitation to powder metallurgy. Powder metallurgy lends itself better to simple shapes, whereas casting lends itself to more complex sections.

It seems that the Vinamold technique extends the scope of the powder metallurgy product, inasmuch as more complex shapes can be made. The pattern must be withdrawn from the die, but, apart from that, it is possible to have different section thicknesses, which would normally require complicated tooling and might not be a practical proposition. Does Penrice consider that the hydrostatic process which he has described, the Vinamold technique, could really be developed in the future by mechanization, rather on the lines of Dr. Jones's remarks, in such a way that it would deal with complex shapes and sections. If so, powder metallurgy could compete with the casting process in terms of economics and quality, surface finish and dimensional precision. Obviously the Vinamold technique cannot be used for the extremely complex sections but can the scope of powder metallurgy be extended into the field of more complex sections in this way? Cast iron may not be a good example to take. The casting technique with cast iron is very highly developed, and competition by the application of the Vinamold technique may be confined to more costly materials such as the carbide materials or, say, turbine blade materials.

There is an interesting point which comes out of Worn's Paper. In ordinary die compacting operations considerable trouble is taken to introduce lubrication, to introduce very fine die finishes in order to reduce friction and achieve uniform density. It seems that the conditions desirable in roll compacting are the complete opposite of those. Worn points out

that rough rolled surfaces are a good thing, that they enable the operation to be carried out with more flexibility, and from his Paper there seems to be no question of introducing a lubricant into the powder mix. That is relevant to green strength as well, and green strength problems are important in certain circumstances.

With regard to the raw material, the author mentions that fine powder, good compacting properties, and short periods of time for sintering are "musts" for the process. That is inherent in the economics of the process; a long sinter treatment for continuous operations of this type is not desirable. The process is intended, however, to make a material which can be rolled in cold-rolling equipment. It may be important that the material as it is made up to the sinter process is impermeable to any contamination which may arise. If for hot work it would be most important, but is this impermeability an important condition and the reason for using fine powders, which will shrink a considerable amount and require only a short sintering time? Does that dictate the use of fine powders? Otherwise, why not use coarser powders with better flow properties and thereby make the rolling procedure less critical?

Williams talks about the use of oxides and graphite. With respect to graphite, would such a barrier act as a lubricant between the sheath and the consolidated powder? Does he want a lubricant, and is the graphite intended to act as a lubricant?

R. F. Tylecote (Metallurgy Dept., King's College, University of Durham, Newcastle-upon-Tyne):

One of the main problems in the teaching of the rudiments of powder metallurgy to students, is the considerable wear and tear on tools, due to the fact that the students do not pay the necessary attention to detail, and it is difficult for the staff to supervize them to the extent which would be desirable. Penrice's Vinamold method might be a way out of this difficulty, but he refers to the fact that Vinamold will extrude through an annular clearance of 0·001 in. on a plunger at 10 tons/in^2 and to the fact that hard rubber rings are effective seals. How are these rings used? How much clearance can be allowed? Can it be of the order of 0·01 in.?

P. E. Evans (University of Cambridge):

At Cambridge work on this question of rolling began in 1952, and still continues. The electrical resistance of the green strip was measured along and across the rolling direction. When extrapolated to short distances, of the order of 1 mm, there was invariably a lower resistance across the strip than parallel to the rolling direction. This appears to be an indication of the fact that there has been more relative movement of the powder particles in the vertical plane or horizontal plane parallel to the rolling direction than in planes across it. This is a very small start in the direction which Dr. Jones has indicated.

Forced flow was also tried. The method was to use an Archimedean screw but there was not any very great improvement; the roll speed still dictated the kind of strip which we obtained. If the powder was forced faster than the rolls wanted to take it, the powder mass broke off and rotated in the screw.

A question was asked about the oxide film on titanium powder. Some sintering of titanium was done two years ago and it was found that the sintering atmosphere was the first hurdle to get over. The pick-up of oxygen and nitrogen seemed to have a worse effect than any already present on the titanium powder.

Another question was why a fine powder should be used rather than a coarse one. In strip produced by rolling, for a given total porosity, fine powders give greater tensile strength than coarse ones. A correlation was found between tensile strength, total porosity and pore size.

C. G. Clow (G.E.C. Research Laboratories):

With ordinary hydrostatic pressure chambers using fluid, on a laboratory scale, we frequently use in our hydrostatic pressing 35 tons/in^2 fluid pressure, which is easily obtainable, and no trouble occurs. Also on Penrice's Paper, and in comparison with ordinary hydrostatic pressing in a fluid, it would seem, since the gel behaves very much like a fluid and there is pressure equal in all directions, the strength of the outer container holding the reversible gel must be as great as is used for normal hydrostatic pressing. It is usually assumed in mechanical pressing that one-third of the pressure is transmitted sideways, and dies are designed on that basis. With a reversible gel it would be necessary to act on the same principle as with a hydrostatic pressing and assume that the same pressure is exerted in all directions on the container.

Why does Penrice specify reversible gels? Is this only for convenience, so that the material can be used again, or is the reversibility a necessary part of the operation? The Paper states that the gel must be dimensionally stable, and if formed under pressure must return to its original shape. Is that for convenience, to enable it to be used again, or would it be possible to use something similar to plasticine?

In Worn's Paper the word "strip" is used in the title. Has any work been done on shaped sections—round or oval sections, grooved sections or channel sections, for example—or has it been restricted to flat strip of uniform dimensions? Was the cladding on the boron carbide material put on at the stage of compaction. With regard to titanium powder, it is very difficult, if not impossible, to get reasonable purity in the sintered titanium using titanium powder. The best method of obtaining reasonable purity is by the hydride process, and this would not have suitable pressing characteristics for compaction.

S. Marton (Mond Nickel Company):

Pressures up to 35 tons/in^2 are easily obtained with normal pressing techniques using water or other liquids. Has Penrice experienced any stiction between the metal powder compact and the Vinamold when high pressures are used. It has been found using a rubber mould, especially when fairly complex shapes with undercuts and so on are produced, that the strength of the rubber and the stiction caused by the pressure applied through the rubber on to the powder are sufficient in some cases to rupture the actual shaped article being produced. Is the stiction less with Vinamold than with rubber? If the Vinamold acts as a fluid, does it penetrate the powder compact if a granular material of coarse particle size is used? Finally, can Penrice give any idea of the accuracy and reproducibility obtainable in making shaped articles?

Mr. Darwin (Babcock & Wilcox):

Some years ago, working with Williams on beryllium, the can shown in the Paper was developed. In the original practice it was thought that before rolling the powder it would be necessary to give it some compaction to get good surface finish. This was originally done by hammering and a fair amount of cracking occurred. Subsequently three billets were given a great deal of hammering and they cracked to pieces. This is hammering before rolling. What experience has Williams of swaging. This is a similar process; has it a similar effect? Subsequent to this, we always hot forged on a press at relatively slow speed before rolling, and no more trouble occurred. Does Williams consider pre-compaction before rolling essential?

On the subject of sheath materials we do not completely agree. With mild steel sheaths a great deal of oxidation occurred, which caused poor surface finish on the material inside. Clearly the oxide on the surface is at fault originally, but the blame may also be ascribed to the mild steel sheath being too soft and transmitting the irregularities on the outside surface through to the beryllium. Perhaps Williams will comment on the use of a liner of stainless steel to eliminate this trouble.

On the question of cost, which has been raised by Dr. Jones and others, the technique is inherently expensive, but a few calculations show that if the pieces concerned are large enough the cost of the manufacture of the sheath and of taking the sheath off afterwards is very small. This would apply in extrusion, but probably not to the same extent in rolling.

D. H. Shute (Production Tool Alloy Co., Ltd.):

Dr. Edwards raised a point in terms of Vinamold and hydrostatic pressing. Penrice illustrated the production of a metal ball, which is a particularly difficult thing to produce by tabletting on an automatic press. If there is a plunger remotely like the shape of the finished ball a line of weakness is present and it cracks, so that to make it as a production job one tends to make a cylinder and machine it to shape. One of the virtues of the Vinamold process is that it is a production job even on small compacts. It is possible to produce a large number of balls in one pressing, and it is quite capable of being mechanized.

To ask whether it is possible to use plasticine instead of Vinamold, is missing the point, because with plasticine, once the pressing is done the mould is destroyed, whereas with Vinamold it is possible to do 100-200 pressings. In other words, it is an approach to mechanization.

AUTHORS' REPLIES

T. W. Penrice: The point has been made by a number of contributors that hydrostatic pressures such as were quoted by Dr. Edwards of 5-10 tons/in^2 are in regular commercial use, and Clow mentioned the use of 35 tons/in^2 on a laboratory scale. Using water as a fluid in virtually the same set-up as that for Vinamold, we have used pressures up to 50 tons/in^2; but the fact is that, but from the point of view of convenience, Vinamold is preferred. These pressures of the order of 30-35 tons/in^2, and even up to 50 tons/in^2, applied to a liquid are only generated by putting the thing into a die container and applying pressure by means of a plunger. It is a form of hydraulic intensifier. That pressure is not generally available as direct delivery from a pump.

It is not, however, merely a question of convenience of handling. The question has been raised of what is the disadvantage of using this idea with the sheath technique. When one tries to do this pressing in a true

fluid, the only shape one can give the powder is that given by the material being used to form the seal between the fluid and the powder. In earlier work it was found, when using material such as rubber sheaths, that they had to be set up inside gauze material or given mechanical support to stop the powder bellying out.

The essence of the use of these gels is that the whole space between the form that one wants and the die wall consists of this pseudo-solid material, and the cavity formed is much less deformed when the powder is put into it and much easier to handle. The effect is that it is possible to work to a much greater degree of accuracy. These things are all relative. It is possible to do them in these different ways, but it is a question of how they perform in practice. It is a question not only of getting the pressure but also of the shape.

On the question of mechanization, in changing from the direct fluid to this material which behaves as a fluid the first step has been taken towards making the process more widely applicable. It has not gone the whole way yet, but some hundreds of pressings can be done in one container without it suffering in any way. A possible point there is the combination. In practice it has been found that mechanical compacts can be done with the usual ease and speed and then use Vinamold, which has multiple cavities, to re-press the material, so that the positive advantages of both are obtained. That is applicable to quite simple shapes. There may be a dozen pressings (and that is not the limit) being re-pressed in this material, so that one has true hydrostatic pressing by treating a mechanical compact.

On the question of clearance, it is true that the Vinamold material would extrude through gaps of less than 0·001 in. on plungers, and it is necessary to use seals. A piece of rubber right across can be used, but this is not usual. There can be a step on the plunger and one or two rubber rings employed, depending on the pressure being used and the hardness of the rubber, say 50 and 70 as the backing, and that can be changed to any degree desired. A clearance of 0·005 to 0·010 in. should be used. The effect of excessive clearance is that a bit of the rubber rubs off, and if it gets jammed it is difficult to eject, but if it is attached to the top ram there is no difficulty. Working with a straight-through cavity, if a bind-up occurs at the top and there is a plunger in the bottom it will very often remove the bottom seal.

As to its development in terms of competing with casting, there is a limitation there. It will possibly compete in those applications where a core is being used. The point was made in the Paper that these cores can be mild steel, and that cannot be done in die sets that have to be hardened to over 62-64 Rockwell from the point of view of wear. To be able to get a number of pressings off a mild steel core is an advantage, and in terms of three-dimensional shapes that seems to be something that is capable of development.

The general dimensional accuracy that can be obtained depends on how accurately the powder can be put into the cavity. Normally a small amount is left for machining. Very much less is left for machining than would otherwise be left if using a true hydrostatic process. It is worth spending a moment on this. If a cavity is filled with powder, at the moment when maximum pressure is reached that cavity will have contracted.

The Vinamold is intimately in contact with the surface. No great penetration of the material into the surface has been observed, but it has certainly got hold of it. When the pressure is released, first of all the Vinamold material recovers from the compression which it suffered, which at 20 tons/in^2 is perhaps about 9 per cent, so that this compact has only to come back about 0·6 per cent and the Vinamold is going back 9 per cent before the point is reached where the Vinamold can start to return to its original dimensions. In doing that the Vinamold starts to expand and acts as though there were tensile grips on the section. There is a limit to the cross-section ratio which any compact will stand because of that effect. Where that is serious is where a metal strip is included and this compact is pressed tightly against the strip, when it is no longer, perhaps, a true hydrostatic pressing, in that part of the surface is blanked off from the Vinamold; but the pressure of the compact on that strip is sufficient so to increase the tensile strength of the component that it is possible to get it out without rupturing. We regularly produce things of, say, $\frac{3}{16}$ in. diameter and 12-15 in. long with that technique, which would not be possible with a direct pressing.

D. K. Worn: Regarding the conditions within the confines of the roll gap, several workers in this field have put forward the idea that the powder is really compacted, using this technqiue, at an angle of bite, so-called, of 7°-8°. In fact, of course, the powder, in the case of horizontally-arranged rolls, starts to compact higher up, in a mild way. An attempt has been made to follow the degree of compaction along these surfaces by incorporating hoods on the rolls which can slide down. By bringing the hood down to a certain point the properties of the green strip are affected very little. When a piece of green strip was coming through, the rolls were stopped, and the space filled up with a suitable liquid which sets the whole mass solid. The rolls were then reversed and the material examined. The result was very much what one would expect. An appreciable effect is noticeable toward the roll gap but higher up there is a certain degree of compaction but the material is still very friable.

The possible orientation of the particles as they pass through the roll gap, has been considered. Findings confirm Evans to some extent. Shrinkage along the length of the strip is rather greater than across the width, but the main worry has been the interference of the normal feeder powder at high rolling speeds.

Consider a powder of bulk density 2 gm/c.c. being rolled at 250 lb/hr. on 8-in.-dia. rolls with a 6-in.-wide strip. About 50 litres of air are being ejected, which results in a flow rate quite capable of floating powder. The main worry on an economic basis, has been to push up the rate of output. The technique of the addition of hydrogen to the raw material is felt to be an answer to some extent. Trouble has also been experienced in forcing powder into the roll gap by mechanical means, especially with fine powders.

Regarding the general slow speed of production, even at 10 ft/min., the point is that the process is continuous. The plant which Dr. Jones has in mind as a possible means of producing strip has rolls only 18 in. wide, and rolling only 5 ft/min. it will produce nearly 1,000 lb/hr. of strip. One man can operate it. It is not difficult to visualize two or three of these in many of the requirements of the metallurgical industry. The output is very small, of course, compared with what may be expected in the steel industry.

The material can be coiled in the green state. One of the difficulties, apart from the economic drawback of a batch process, is that there are difficulties in supporting the turns of strip at high temperature. Welding frequently takes place between adjacent turns, and except in special instances, where an expensive type of material is being produced, the continuous technique is preferred.

The point raised by Hooper about oxides and other impurities in rolled strip is interesting and presumably was referring to the effect of these on possibly anisotropic finished products. Difficulties have been encountered on these lines and attempts were made to retain some very fine oxides which are strung out, and some mechanical anisotropy was found. It was necessary to make sure that the oxides were reduced. Probably, in Hooper's case the problem was more difficult. With regard to crystal anisotropy, there is nothing spectacular about the direct rolling process and the material behaves like any other; that is, it depends entirely on the process schedules. It has been reported that the direct rolling process, by virtue of the fact that randomly oriented particles are taken, eliminates problems of earing; but if porosity is eliminated, earing and so on is just as liable to occur as with conventionally-produced material.

Reference has been made to lubricants. In some instances lubricants have been added to improve bonding properties, but when considering large-scale production by this method the economics do not really allow the addition of lubricants. It is necessary to cater for the removal of the lubricant in sintering.

In reply to Elliott, generally speaking it is correct to say that a raw material is chosen if it is available primarily to get good green strength and a good rate of sintering, so as to be able to sinter in the minimum time. That immediately implies a fine powder and one of regular shape. The question of permeability is quite important, because in many cases the sintering process is relied on to purify the material of odd traces of carbonaceous matter and oxides, so that some measure of permeability should be retained in the sintering operation, and it is a mistake to try to eliminate that permeability or porosity too quickly by processing before all the oxides and carbides are removed.

The cladding of the carbide material had not been put on at the stage of compaction. It was tried, but all attempts to activate the surface of the spring steel, even with nickel inter-layers, did not make it possible to bond powder effectively on a solid piece of metal on a continuous basis.

J. Williams: In reply to Dr. Jones, it is impossible to answer questions on the economics of the process in a general sense; each individual material will have to be treated as a separate entity and assessed separately.

In reply to Elliott, graphite has been used as an interlayer, and it is quite effective when sheath rolling material.

In reply to Darwin, with the swaging of powder sheaths a certain amount of surface cracking occurs, but this cracking does not appear to penetrate right through the section; it is more like surface crazing. This point has not been assessed completely yet. Pre-compaction would be preferred, it seems to give a better surface to the product when sheath-rolling beryllium.

(To be continued)

The illustrations on the opposite page show the various stages in the production of thermostat bellows

Top Left: Drawing and ironing of the brass tube from which the bellows are manufactured is performed by machines such as the one illustrated. Capable of producing tubes of 0·0045 in. wall thickness, these machines enable the tubes to be drawn some 10 per cent thinner than was possible before, thereby ensuring a more sensitive bellows, resulting in more efficient thermostats

Top Right: The sequence of preparing the brass from which the bellows are manufactured is clearly shown. Starting with a stamped out disc there follow three "cup" forming and three tube "ironing" processes which gradually increase the length of the tube. A remarkable feature is the small number of operations performed to produce the required length of tube to the necessary accuracy of wall thickness

Centre Right: This machine produces two bellows from one 18 in. length of brass tube automatically, an operation which previously required the services of a highly skilled person who had to spin these bellows by hand. Resulting from the speed at which these bellows are produced, thermostat production has been stepped up by at least 20 per cent

Bottom Left: High frequency soldering machines with special sub-assembly rigs similar to the one shown here perform all the soldering operations required for the completed thermostat semi-automatically. This illustration shows the rig and indexing table set up for the attaching of the "bellows plates" and valve stem to the bellows

Bottom Right: This is the "conveyorized" calibrating rig. On the left can be seen the electronic control unit which maintains the temperature of the calibrating tanks to within $\pm 1°$C. of the calibration temperature. The nearly completed thermostat is passed through these tanks and whilst in transit the thermostat valve is finally soldered in place and the then completed unit is tested and its calibration checked before its eventual ejection and visual inspection

FABRICATION

A MACHINE which, for the first time, enables the all-important metal bellows of thermostats to be spun and fashioned mechanically and to a greater degree of controlled accuracy than was possible by manual methods, has made possible a 20 per cent rise in the output of thermostats from the Putney Vale factory of K.L.G. Sparking Plugs Limited, part of the S.M.A. group of companies. Equally important are other machines which deep-draw and "iron" the brass stampings into thin walled tubes, some 18 in. in length, and it is from these tubes that the bellows are automatically formed. These machines have been developed by engineers of Smiths Motor Accessory Division.

The new method of drawing enables the tubes to be drawn 10 per cent thinner—at 0·0045 in.—than was possible before, resulting in more sensitive bellows and, in consequence, a more efficient thermostat.

Reduction of the tube drawing process to three draws and three ironing operations, with annealing interposed between stages, is itself a very considerable technical achievement, resulting in uniform wall thickness for each tube to a very accurate degree. Even more remarkable, though, is the substitution of automatic for hand spinning in the forming of the bellows. This highly skilled job was formerly done by operators using hand tools. Now, the new and patented Smiths' machine takes the tube and, with a "finger" insert, pulls it outward against a guide which forms a series of convolutions of predetermined length and diameter. Two bellows are spun, in a matter of seconds, from one length of tube. When each bellows has been formed to a previously calculated size, the machine cuts it off automatically.

To match the increased rate of output of bellows made possible by the new methods, semi-automation has been carried to the assembly of the complete thermostats, too. A conveyor belt carries all the component parts to the operators of each sub-assembly point. The operator removes whichever item is required from the conveyor and solders it in position by using a specially adapted high frequency soldering unit. This same conveyor ensures that all the components are perfectly clean.

As each item comes away from the press or form tool it is attached to the conveyor and, en route to the sub-assembly point, is passed through an electrolytic cleaning process.

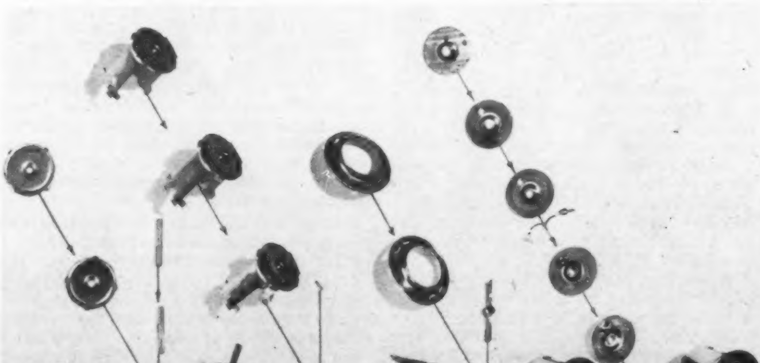
From the moment the bellows come off their forming machine to the completion of the actual thermostat, very little "handling" of the components is evident, the assembly cycle being that the bellows are first spin dried to remove surplus moisture and then annealed to relieve manufacturing stresses. The ends are cleaned and tinned on one of the many different rigs attached to the various high frequency soldering units prior to having the "bellows plates" and valve stem soldered in position.

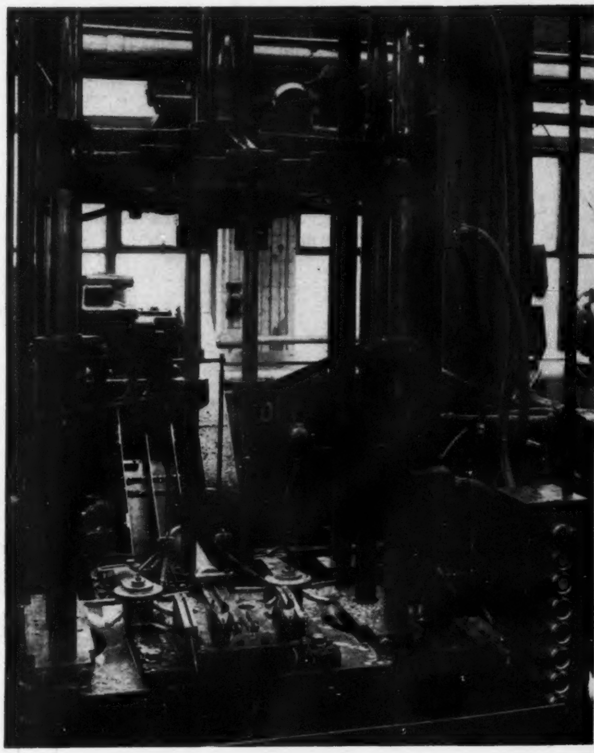
As soon as this operation is completed, the unit so far assembled is ejected automatically from this rig and passed by conveyor belt to the next sub-assembly stage, which is the fixing of the carrying bracket to the bellows. By means of an indexing table attached to the high frequency soldering machine, the bracket is first soldered in position, then a solution of methylated spirits and water (the thermostat controlling fluid) is injected through a small hole in the bracket and into the bellows. Air is then evacuated from the bellows via this hole and, whilst still under vacuum, a taper pin is fed into the hole and pushed home prior to final sealing by soldering the pin in place.

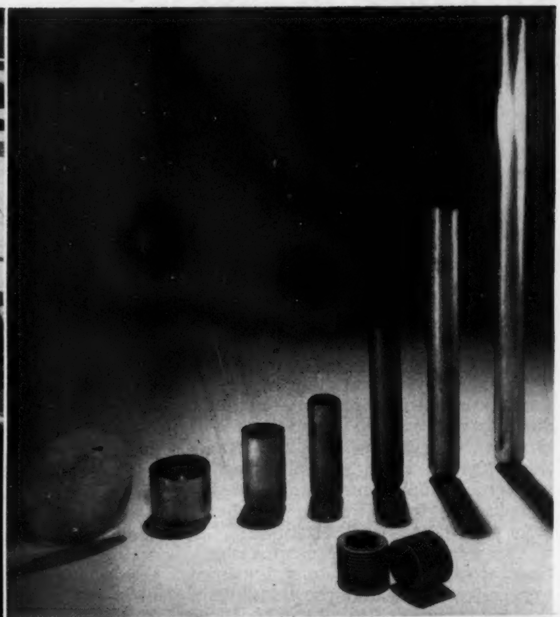
Next stage is the attaching of the valve seating to the bracket, and this is achieved by a patented "T slot" fixing. Whilst in position, the seating is trimmed to its correct size and the valve is assembled. The completed unit is now placed on a special "conveyorized" calibrating rig, where it passes through the water-filled calibration tanks, the temperatures of which are electronically controlled to $\pm 1°$C. During passage through these tanks, the thermostat valve is finally soldered in position whilst still in water by the last of the many high-frequency soldering machines used in this method of thermostat manufacture.

Testing, too, is performed on this same conveyor. The thermostat is stressed to be beyond its normal operating temperature by virtually

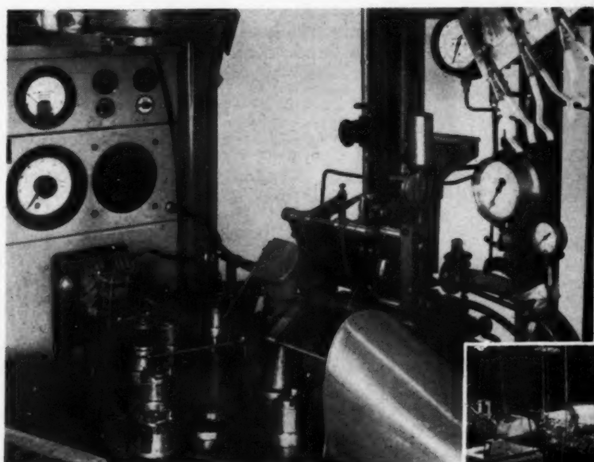
The component parts which make a complete thermostat are shown in this illustration. By following the arrows from left to right the order in which they are assembled can be easily followed







OF THERMOSTATS



boiling it. Its actual calibration is checked to within the required tolerance, and a check is also made to ensure that the valve is fully open 15°C. above its calibrated opening temperature as a safety precaution. From here, the units are automatically ejected, visually inspected, and packed ready for despatch at the rate of 25,000 per week.

Research Progress

Magnesium-Lithium Alloys

BY RECORDER

THE relatively low ductility of magnesium and many of its alloys can be attributed to the limited deformation processes available in the hexagonal structure. The poor ductility not only restricts the number of applications for such materials but also gives rise to difficulties in fabrication. The discovery, some years ago, that magnesium-lithium alloys possessed considerable room temperature ductility, therefore, aroused much interest, especially when it was established that at alloying levels of 10-15 per cent lithium a cubic structure was formed and the above improvements were even more pronounced.

The next development — investigations of ternary and more complicated systems—showed that the ductility of the binary magnesium-lithium alloys could largely be retained in materials that could also be age-hardened to relatively high proof and ultimate tensile strengths. Since the alloys were very light, excellent strength: weight ratios were obtained, certainly sufficient to open out many commercial uses.

It was discovered, however, that the desirable properties of the hardened alloys were unstable and, even at ambient temperatures, softening tended to occur at an unacceptably rapid rate. Further alloying additions to obtain stability were, therefore, sought, as, for instance, in the work of W. R. D. Jones and G. V. Hogg.[1] This research started from the basis that cadmium, zinc and aluminium give high but unstable properties, and silver, copper, tin and cerium give lower but stable properties. It was assumed likely that additions of elements in this second group would confer stability on ternary alloys containing an element of the first group — an assumption which would appear to be difficult to justify considering the complexity of the effects being investigated.

The alloys chosen seem to have been selected usually to give a magnesium:lithium ratio of 88:12 with either 7·5 per cent zinc or 9 or 18 per cent cadmium. The stability of specimens treated for 4 hr. at 450°C. and quenched was assessed by hardness measurement after various times of ageing at 16°, 50°, 75° and 100°C.

It was found that quaternary additions of silver (up to 3 at. per cent) had the greatest influence on stability in both the zinc- and cadmium-bearing alloys, and at 16°C. no drop in hardness occurred after times in excess of 100,000 hr. However, ageing at the higher temperatures, i.e. 50°C. and over, tended to give an initial hardness rise, followed quickly by a fall in times usually less than a few hundred hours.

Jones and Hogg concluded that the stabilizing effects of the additions were related to their valency in such a way that a reduction in electron:atom concentration improved stability and an increase in e/a lessened stability. This view was tested in a series of experiments in which additions of 1 at. per cent antimony or nickel were made to the ternary alloy containing zinc. Although, as expected, antimony reduced the stability, nickel, too, caused a reduction to occur in the ageing time needed to give a 5 per cent decrease in maximum hardness. The use of the latter criterion as an indication of stability appears to be somewhat arbitrary, and no comment is made about the effects of the additions on the form of the hardness:time curves (which nickel influences very considerably).

Several of the alloys showing improved stability were heat-treated in various ways and the mechanical properties determined. In general, ageing treatments at 16° or 75°C. after hot rolling were found to give only moderate improvements in strength (over the ternary alloys), the ductility usually dropping slightly. Solution treatment at 450°C., followed by ageing at 75°C., either for 200 hr. or to maximum hardness, induced severe brittleness, several of the specimens cracking during ageing. This was particularly the case with alloys containing zinc. The ductility could be improved, especially in the cadmium-bearing materials, by cold rolling, a treatment thought to break up grain boundary films of precipitates. The properties so obtained were retained after at least six months' storage at room temperature.

It is regrettable that Jones and Hogg make no mention of the sodium contents of their alloys, since it is well known that small amounts of this element—so likely to occur in magnesium-lithium materials — can have marked effects on the properties. It may safely be assumed that precautions against contamination with sodium were taken, and that the results are not as suspect as those presented in a Paper by M. W. Toaz and E. J. Ripling.[2] These workers describe the properties of three binary magnesium-lithium alloys containing, nominally, 4, 6 and 11 per cent lithium. The latter material, however, also contained 0·068 per cent sodium, a quantity relatively so large that the alloy would be more properly described as a ternary of magnesium-lithium-sodium than as a binary.

However, although the results of Jones and Hogg are not likely to be so determined by the sodium content, a recent note by R. J. M. Payne and J. D. L. Eynon[3] shows that the properties of magnesium-lithium base alloys may be affected by the presence of very small amounts of sodium. Thus, in a series of as-cast specimens of alloys containing 13·5 per cent lithium and 0·0085, 0·0070, 0·0025, 0·0019 and 0·00025 per cent sodium, the elongations shortly after casting were 39, 39·5, 44, 39 and 42 per cent respectively. On ageing, however (for 24 hr. at 200°C.), the comparable values were 0, 9, 35, 36·5 and 41 per cent respectively. Other examples show that similar effects can be obtained under less severe heat-treatment conditions. Thus, in an alloy containing 12 per cent lithium, 0·017 per cent sodium, the elongation decreased from 39 to 6 per cent on allowing the material to stand at ambient temperatures for six months, and in an alloy containing 12 per cent lithium, 0·0105 per cent sodium, the original elongation of 42 per cent was reduced to 34, 19 and 4 per cent by heat treating specimens at 100°C. for 1, 8 and 64 hr. respectively. It seems clear that should a high-strength magnesium-lithium base alloy be found which is stable at room temperatures, the practical problem of producing the material with an acceptably low sodium content may be a serious obstacle to commercial applications.

References

1 W. R. D. Jones and G. V. Hogg; *J. Inst. Metals*, 1956-57, **85**, 255.

2 M. W. Toaz and E. J. Ripling; *ibid*, 1956-57, **85**, 137.

3 R. J. M. Payne and J. D. L. Eynon; *ibid*, 1957-58, **86**, 351.

Obituary

Dr. M. Lissauer

WE regret to record the death of Dr. Meno Lissauer, chairman of the board of Associated Metals and Minerals Corporation, New York. He was also chairman of Leopold Lazarus Limited, and Spartan Steel and Alloys Limited, London.

Born in Lübeck, Germany, Dr. Lissauer formed his own business under the name of M. Lissauer and Co., in Cologne. Leaving Nazi Germany in 1937 for Holland, his headquarters were transferred to New York in 1941. Until shortly before his death he continued to be active in the international operations of the metal and ore trading business.

Industrial News *Home and Overseas*

A Bicentenary

A special service is being held on Sunday next at Bromborough Parish Church to mark the bicentenary of the Merseyside engineering firm of **Fawcett Preston and Company Ltd.** The programme of bicentenary celebrations began on Wednesday of this week when Sir Charles Westlake, chairman of Metal Industries Ltd. and of Fawcett Preston, opened an exhibition, "Fawcett, Past and Present," at Bromborough consisting for the most part of photographs, old documents and drawing, and models.

Yesterday (Thursday) there was a luncheon at Port Sunlight at which more than 250 guests were present, including a number of representatives of overseas governments. The Lord Mayor of Liverpool proposed the toast of the company at this function, and Sir Charles Westlake replied. To-day, on the site of Fawcett's original factory in Liverpool, the Lord Mayor will unveil a plaque commemorating the construction by William Fawcett in 1817 of the first marine engine to be built on Merseyside. Other functions have also been arranged in which the company's 600 employees and their children will take part.

Tubes and Pipes

Information has been passed by the British Consulate-General at Los Angeles to the Export Services Branch of the Board of Trade that Mr. Louis Massing, the vice-president of Globe International of California Inc., 3221 South La Cienega Boulevard, Los Angeles, is seeking United Kingdom sources of supply of copper tubing of all types, seamless, mechanical tubing, line pipe, aluminium tubing, and any other types of tubing that U.K. firms are currently exporting. The firm wishes to purchase on its own account.

The U.S. firm are engaged in the importing of industrial machinery and industrial chemicals, and it is suggested that United Kingdom manufacturers interested in this enquiry should write by air mail direct to Mr. Louis Massing. It is stressed that quotations should show by f.o.b. and c.i.f. prices in U.S. currency.

New Copper Find

It is reported from Toronto, Canada, that the uncovering of a new high-grade ore zone is announced by Opemiska mines. Diamond drilling outlined a section of ore 150 ft. long, averaging 5·04 per cent copper, with an average width of 10·5 ft. The zone was called No. 8, and lay between the 400 and 525 ft. levels of the Springer mine.

A New Company

Due to the increasing demand over the past years for "Jeltek" protective clothing, the manufacturers, **J. E. Lesser and Sons Ltd.,** announce the formation of a new company, to be known as **Jeltek Limited,** to undertake the manufacture and marketing of this product. The change-over will take effect from August 1 next, when Mr. M. Soffa, at present sales manager of the "Jeltek" division of the Lesser company, becomes general manager of the new company.

Coincident with this announcement, the company has released its 1958-59 brochure and price list, which contains full details of the range of protective clothing produced, with many illustrations.

Midland Branch Office

Larger premises have been acquired by **M. L. Alkan Ltd.,** for the Midland branch office at 162-3 High Street, Deritend, Birmingham, 12. This move will enable the company to provide better facilities and more prompt attention for their customers in the Midlands area.

Bronze and Brass Founders

A meeting of members in the London area of **The Association of Bronze and Brass Founders** is to be held at the Clarendon Restaurant, Hammersmith, London, on Wednesday next, June 11, commencing at 11.45 a.m. At this meeting there will be a report and discussion of current activities of the association.

Following luncheon, three films will be shown and introduced by Mr. Frank Hudson. The films are "Hand and Machine Moulding," "After the Shake Out," and "New Ideas at Work in the Foundry."

Aluminium in Packaging

Arranged by the **Aluminium Development Assocation,** the Symposium on Aluminium in Packaging, which is to be held at the Savoy Hotel, London, on Thursday next, June 12, will be divided into two sessions. The morning session will be devoted to aluminium as a packaging material, when Mr. D. C. G. Lees, M.A., A.I.M., will introduce three separate Papers on the subject.

The afternoon session will deal with uses of aluminium in packaging, when five Papers will be introduced by Dr. E. G. West, B.Sc., F.I.M. The chairman of the morning session will be Mr. S. E. Clotworthy, B.Sc., M.I.E.E. (President of the Association), and presiding over the afternoon session will be Dr. Maurice Cook, D.Sc., Ph.D., F.I.M. (chairman, Imperial Chemical Industries Limited, Metals Division).

A Removal

We are informed by **Vacu-Blast Ltd.** that they have now moved to new and larger premises at Bath Road, Slough, Bucks., where their offices and works will be combined. This move will facilitate increased production of Vacu-Blast equipment to meet the ever-increasing demand.

The company are designers and manufacturers of the Vacu-Blast closed circuit system of shot blasting, and during the comparatively short time in which the system has been in production its applications have increased to an extent wherein a wide range of constructional and process industries are using the system for an increasing number of shot blast applications.

Clean Air Act

From Sunday last, June 1, the remaining provisions of the Clean Air Act became effective, and industrial and commercial premises are now called upon to operate their plants with a minimum emission of dark smoke, grit and dust. Although most people are aware of the Act, its actual requirements may not be so well known, and the **National Industrial Fuel Efficiency Service** has prepared a four-page leaflet containing some useful information on the implications of this Act.

In addition to a general description of the purposes of the Act, N.I.F.E.S. provides some useful notes for the guidance of industry, and also includes a reproduction of the Ringelmann Chart, which is referred to in the Act itself.

Change of Name

At an extraordinary general meeting of British Chrome and Chemicals Holdings Ltd., held last week, the proposals of the board of directors that the name of the company should be changed to **Associated Chemical Companies Limited,** and to alter the articles of association accordingly, were duly passed.

New Separating Screen

Now adopted as standard equipment for the Roto-Finish Midget barrelling machine (DW 16-16-2) is a new type of screen tray. This consists of a sheet steel tray, the base of which is perforated with square holes. A set of six screen trays with different sizes of screen is provided as standard equipment with each of these machines.

The manufacturers of this screen—**Roto-Finish Ltd.**—claim the following advantages for it:—(a) more accurate separation of chips from parts, (b) a stronger construction which avoids bending under the weight of chips and parts, (c) because of the tray shape and the integral construction, parts and chips cannot lodge between the edge of the screen and its support, and (d) after separation of the chips from the parts, the screen tray serves as a convenient container for the parts.

European Sales Drive

One of the biggest sales drives in Europe undertaken by Kelvin Hughes Marine and Industrials Division began on Monday last. On that day, two specially equipped mobile demonstration units were driven aboard a converted tank landing craft at Tilbury to begin tours of Eastern Europe and Common Market countries.

Kelvin and Hughes (Industrial) Ltd. is despatching its specially built unit on a four-month tour of Eastern Europe. It will visit Poland, Czechoslovakia, Hungary, Rumania and Yugoslavia. Equipment for promoting boiler plant efficiency, for use in hospital operating theatres, and for the detection of cracks in metal are included.

Kelvin and Hughes (Marine) Ltd. is sending its mobile unit — which has already undertaken several tours in this country—on a two-month tour of Polish, Western German and Belgian ports.

Russian Aluminium

Some comments have been made recently in London regarding the price of Russian aluminium, which is not too clearly defined at the moment, according to trade sources.

There has been a certain amount of talk of the material offering at below £170 per ton c.i.f. United Kingdom, although usually reliable sources say they have not encountered offers cheaper than about £170. The trade here, moreover, is reported to be unwilling to enter into

fresh commitments, presumably because it is covered for the time being, while the question of the Aluminum Company of Canada's application for an anti-dumping duty on Soviet metal brought into the U.K. has still to be settled

The Russian price compares with the U.K. contract price of £180 per ton delivered, less the 2 per cent "loyalty discount," equivalent to £3 12s. 0d. Thus, Russian metal on a delivered basis of about £174 would not be all that cheaper than Canadian, trade quarters point out.

In the first quarter of the current year, U.K. imports of Russian aluminium totalled 4,438 tons, accordng to the British Bureau of Non-Ferrous Metal Statistics. During the same period, imports from Canada totalled 26,279 tons. For the whole of 1957, the corresponding figures were 15,450 tons and 152,620 tons. Possibly a good part of this year's arrivals from Russia were against old purchases.

Electronics Exhibition

This year's Electronics Exhibition and Convention, organized by the Northern Division of the **Institution of Electronics,** will be held at the Manchester College of Science and Technology during the period July 10 to 16 (excluding Sunday) next. It will include the largest British display of electronic devices held outside London, and will incorporate the following sections:—

A manufacturers' section where will be displayed the electronic products of over 75 manufacturers from Britain, America, and the Continent. A scientific and industrial research section, and an extensive programme of lectures and film shows on a wide field of electronic topics. Items of interest to members of all branches of science and industry will be included.

Complimentary exhibition admission tickets may be obtained from the various exhibitors or by forwarding a stamped, addressed envelope, from Mr. W. Birtwistle, honorary exhibition organizer, The Institution of Electronics, 78 Shaw Road, Rochdale, Lancs.

Developing Export Trade

Recently returned from a 30,000 mile tour covering Pakistan, Singapore, Hong Kong, Australia, New Zealand and the United States, Mr. Nicholas Gillott, managing director of **Joseph Gillott Ltd.,** Dudley, emphasizes the importance, in developing export markets, of personal contacts with overseas agents, particularly for the smaller firms. As manufacturers of special pen nibs for artists and draughtsmen, Joseph Gillott Ltd. export over 25 per cent of their total production to the United States.

Fire Protection

In developing the Swish Aerosol fire extinguisher, **Deb Chemical Proprietaries Ltd.** have provided an inexpensive fire fighting appliance for use beside each workbench, machine, or office desk, to deal with minor outbreaks of fire instantly before they become major conflagrations.

This new type of extinguisher contains 12 fluid oz. of extinguishing liquid, released as a powerful jet spray by depressing the discharge nozzle; the release of the nozzle completely cuts off the jet. The spray is said to douse flames instantly and carries for 6 ft. with a 3 ft. diameter coverage. The extinguishing fluid used is a non-conductor of electricity, consequently "Swish" is safe and effective on all fires whatever their cause.

Sold in cartons of one dozen extinguishers, complete with fixing brackets, this unit is priced at 12s. 11d. per extinguisher.

Visiting Denmark

Overseas technical salesman for the speed nut division of **Simmonds Aerocessories Ltd.,** Mr. R. G. Tant is visiting Denmark for two weeks. While there he will demonstrate to the company's agents and customers the latest applications of Spire speed nuts in all branches of light engineering and product assembly.

Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week totalled 18,874 tons, comprising London 5,887, Liverpool 11,797, and Hull 1,190 tons. Copper stocks totalled 16,477 tons, and comprised London 10,209, Liverpool 5,908, Birmingham 185, and Swansea 175 tons.

Aluminium Extrusion Plant

The British Embassy at Havana has informed the Board of Trade that the firm of Ventanas Tropical de Cuba, S.A., of Apartado 69, Santiago de Cuba, have requested to be put in touch with United Kingdom manufacturers of complete plant for aluminium extrusions, including presses, boilers, extrusion stretchers, etc. Their production will be used in the aircraft industry, and for doors and windows and other allied lines.

Manufacturers interested in this enquiry are advised to write direct to the Cuban firm, and quotations should be, if possible, in U.S. dollars c.i.f. Havana.

New Offices Opened

On Monday last the new Birmingham store and sales office of **British Insulated Callender's Cables Ltd.** were officially opened by Mr. W. S. Lewis, C.B.E., J.P., chairman of the Midlands Electricity Board. These new premises are situated at 67-77 Holloway Head, Birmingham, 1, and will accommodate the staff of the Birmingham branch manager, Mr. P. Greaves, and that of the Midland regional manager, Mr. A. R. Leith

The store has a floor area of 11,000 ft^2, and there is 3,000 ft^2 for the office accommodation. Some two million yards of insulated cable and very large quantities of winding wires, cable accessories and jointing compounds will be held in the store, thus enabling the company to double stocks of cable held locally, formerly kept in a number of temporary stores.

Aluminium Foil Development

As a result of the ever-growing demand for aluminium foil for an exceedingly wide variety of purposes, it has been announced this week by **Venesta Limited** that there has now been established the **Venesta Foil Division.** This event sees the fruition of a complete plan of co-operation and co-ordination between Venesta Limited and the Empire Aluminium Company Ltd., the latter with its works and plant at Glasgow.

The full significance of this announcement is made clear by the fact that the new Division, in addition to having the advantage of the four new mills which were installed at Silvertown, London, last year, and the modernization and expansion at the Glasgow factory, will be able to meet these increasing demands for aluminium foil in a manner much more satisfactorily than before. These demands have risen from 4,500 tons in 1946 to more than 21,000 tons in 1957, and there is no doubt that this demand will go on increasing.

The work of this new Foil Division is to ensure that, whilst each company retains its own entity, personnel and sales organization, there will be complete co-operation and co-ordination between the two. By the implementation of this work, three main advantages arise: (a) there is complete co-operation between the sales departments, which are integrated at top level; (b) there are two factories—one in London and one in Glasgow—to safeguard supplies, and (c) the establishment of a combined research organization ensures consistently high quality.

It was on account of the steady growth of the Venesta company that more rolling mills were installed at Silvertown last year, and at about the same time the company also acquired the Acme Tea Chest Company of Glasgow, and with it, its subsidiary, the Empire Aluminium Company and the latter's sales organization, John North (Foils) Ltd. It is understood that the new Foil Division will also incorporate the Venesta tube department, as obviously collapsible metal tubes are in the same field.

Copper Price Study

News from Santiago is to the effect that various United States agencies are at present studying the problem of copper prices and markets, and other metal issues, according to Mr. Walter Howe, the new American Ambassador to Chile. Speaking at his first press conference since presenting his credentials on Sunday, Mr. Howe said he thought that within time some settlement would be reached which, in any case, would consider the interests of both domestic and foreign mining industries.

A Buyer's Guide

A new publication has just been introduced by the **Purchasing Officers' Association** which is, in fact, a buyer's guide to the drafting of purchase order conditions. The growth of trade associations and the sellers' market which has been in evidence during and since the war have both combined to strengthen the position of supplers who refuse to do business otherwise than on the basis of standard conditions issued by themselves or their associations.

These conditions are usually lengthy and difficult to read because they are printed in small type, and it has generally been found that the protection that they seek to give the seller is far greater than is reasonably necessary; the supply situation has been such that frequently buyers had no option other than to accept these conditions. It is true that in practice a seller, particularly if he is dealing with a well-established and valued customer, is unlikely to stick strictly to his legal rights in the event of a genuine complaint, but this is something on which it would be unwise for a purchasing officer to rely.

The ideal would be for buyers and sellers to agree on a basic set of conditions nationally but, human nature being what it is, this will take a long time to achieve. The Purchasing Officers' Association has, therefore, published this new booklet with two objects in view:—(1) in the short term to act as a guide to its members in their efforts to establish fair trading terms for both buyers and sellers

alike, and (2) in the long term to provide a basis for the establishment of a set of standard conditions agreed nationally between buyers and sellers. The association's economic survey committee and its legal advisers have spent considerable time in drafting the booklet which, it is hoped, will fill the need for a model set of standard conditions of contract, which will be suitable for a wide range of industries.

Copies of this booklet are available from the association (price 5s. 0d. post free) at its headquarters, Wardrobe Court, 146a Queen Victoria Street, London, E.C.4.

Inco-Mond Magazine

In the latest issue (No. 6) of this magazine, the leading article deals with the use of nickel-containing stainless steel in the manufacture of fatty acids. Among the other articles are descriptions of a unique air-conditioning process at one of Inco's mines and the use of iridium type alloys in the manufacture of Swan pens. Other uses of Mond products in portable electric tools, marine chronometers, glass figurines, and equipment used in the dairy for teaching students at Aberystwyth University are featured. There are many excellent illustrations in this issue, and copies of the magazine may be obtained free on request from The Mond Nickel Company Limited.

New Weld Cleaner

Introduced by **North Hill Plastics Ltd.** is "Pelox," a new, non-corrosive, weld cleaner for stainless steels. This cleaner is specially formulated for cleaning and neutralizing after electric welding operations (including argonarc, atomic-arc and other methods), and the makers claim a number of important advantages for it.

News from Scotland

It is reported that **Harland Engineering Co. Ltd.** are shortly completing test facilities for heavy pumps, and have spent £202,400 during 1957 on modernization. Reorganization of the works has been undertaken on the basis of reports prepared by consultants, and expanded output is expected from these factors. Boiler feed pump business from home and overseas customers has expanded, with a substantial volume of business from the atomic energy projects. Hydro-electric business has been somewhat reduced, only one large-scale order having been booked over the period under review, this being for Jamaica.

Wallacetown Engineering Co. Ltd., of Ayr, are to develop their works there, and have received permission to acquire ground at Heathfield for this purpose. Details of the development remain to be indicated. **Bonar Long and Co. Ltd.** are to erect a heavy engineering shop at East Kingsway as an extension to their existing premises. The new area will be used to facilitate production of transformers in the 132 kV class. The floor area will be 50,000 ft^2 and modern handling equipment will be included. The development will be carried out over the coming 12 months. Cost is estimated at between £150,000 and £200,000.

An Annual Report

The severe fall in the prices of lead and zinc during the last eight months of the year caused a substantial reduction in the trading profits of the Consolidated Zinc Corporation Limited for 1957, which amounted to £4,461,194, compared with £6,250,323 for 1956, according to the chairman's statement in the annual report. The Zinc Corporation Limited again increased ore production and achieved a lower cost per ton of ore at Broken Hill than for the previous year. Nevertheless, the reduced average prices realized for lead and zinc concentrates resulted in a much lower profit than in 1956. Consolidated Zinc Proprietary Limited had a satisfactory year and showed a considerably increased profit. This was due, in the main, to better results being achieved by the acid and superphosphate business of Sulphide Corporation Pty. Limited, and to satisfactory profits earned by Titanium and Zirconium Industries Pty. Ltd. Imperial Smelting Corporation Limited had a lower output of zinc, but deliveries of alloys were considerably greater than in 1956. Lithopone sales were at a reduced level but sales of other pigments compensated for this decrease, while sales of sulphuric acid were maintained. Profit margins on most products were reduced and, overall, the profits from trading for the year in the United Kingdom were somewhat less than in 1956.

Higher outputs and increased mining efficencies were again achieved at the mines of the Zinc Corporation and New Broken Hill Consolidated at Broken Hill. The Zinc Corporation mined a total of 762,912 tons of ore for a production of 90,820 tons of lead, 2,198,457 ounces of silver and 139,684 tons of zinc concentrates, compared with 80,625 tons of lead, 2,000,317 ounces of silver and 133,661 tons of zinc concentrates in 1956. New Broken Hill Consolidated mined 722,722 tons of ore for a production of 64,794 tons of lead, 1,704,892 ounces of silver and 154,325 tons of zinc concentrates, compared with 47,950 tons of lead, 1,206,308 ounces of silver, and 137,990 tons of zinc concentrates in the previous year.

The lead content of ore mined from the Zinc Corporation leases shows an increase at 12·7 per cent, as compared with 12·2 per cent reported last year. However, as mentioned in previous statements, a trend towards lower overall grades must be expected in future as more production is drawn from the lead lode orebodies below No. 16 level. The grade of ore mined by New Broken Hill Consolidated was 9·8 per cent lead, 2·6 ounces of silver and 12·0 per cent zinc, compared with 8·7 per cent lead, 2·2 ounces of silver and 12·9 per cent zinc in the previous year.

Trade with Canada

An interesting report on the market for hydraulic presses has been prepared for the Board of Trade by the U.K. Trade Commissioner Service in Canada. In its summary, the report says that the large variety of comparatively small industries in Canada using hydraulic presses means that requirements for any one type are likely to be small. The users are well catered for by Canadian makers, some under licence from the U.S.A., and by U.S.A. makers, who put themselves out to meet the requirements of individual customers.

It is suggested that the prospects for United Kingdom makers are probably best on standard types of presses. The pre-requisites for doing business are competitive deliveries and good after-sales service. These must be backed up by attractive prices.

In a section dealing with demand, the report says that in the metalworking field, the increasing development of primary iron and steel production offers prospects, e.g. for forging presses. The demand for deep drawing presses in Canada is expected to improve as industry, in its expansion, reaches the appropriate economic levels of production. At present, due to a combination of comparatively small off-take per design, and high wage rates, deep drawings are often fabricated by the adjacent United States industry. The demand for deep drawing presses is thus limited to the larger units of industry. There has been a fair demand for extrusion presses for aluminium and copper. So far as is known, there are no steel extrusion presses yet in Canada, but it seems likely that a demand for such presses may arise in Ontario.

The motor industry in Canada has been one largely of assembly, but there are signs of further development: Mack Trucks Ltd. have been reported to have acquired 50 acres at Trois Rivieres in the Province of Quebec for the partial manufacture and assembly of their commercial and fire vehicles. The aircraft industry depends in large measure upon Government contract, and at the moment, the industry is pessimistic about expansion possibilities.

The railways have a fair demand for hydraulic presses for their railroad shop operations, which can reasonably be expected to expand as economic development and opening up of the country progresses. Wheel presses for mounting and demounting wheels are required to meet American rolling stock sizes. Forcing presses up to 100 tons are used for bushing and light straightening, and heavy straightening presses are employed in capacities up to 250 tons. The latter are usually of the open gap type with throat dimensions up to 30 in.

Primary plastics appear to have good prospects of expansion. Both rubber and plastics secondary industries provide a healthy market for a wide range of hydraulic presses.

In the section dealing with customs duties, etc., it is pointed out that for presses of a class or kind made in Canada the import duty on British presses is 10 per cent; on U.S.A. and other (e.g. German) presses, the duty is 22½ per cent. If of a class or kind not made in Canada, British presses enter duty free; on other presses the duty is 7½ per cent, which, however, is subject to a 99 per cent refund if such equipment is to be used in the motor car or aircraft industries. Data is given in Appendix "A" on rulings made under the definition "Made in Canada," but because of the scope of this phrase, and changing conditions, it will normally be advisable to obtain a customs ruling in each case.

Forthcoming Meetings

June 11—National Association of Non-Ferrous Scrap Metal Merchants. Grosvenor House, Park Lane, London, W. Annual general meeting and luncheon, 11 a.m.

June 11 — Association of Bronze and Brass Founders. London Area Meeting. Clarendon Restaurant, Hammersmith, London, W. 11.45 a.m.

June 12—The Aluminium Development Association. The Savoy Hotel, London, W.C.2. Symposium on Aluminium in Packaging. 10 a.m.

Metal Market News

TRADING on the Exchange last week was limited to four days, for Monday was a holiday, and the turnovers were reduced accordingly. Throughout the period, the ever-deepening crisis in France and the extremely serious outlook in this country in the matter of London's transport acted as a brake on optimism but, nevertheless, the tone was steady if not firm, for the news from the U.S.A. was fairly favourable and Wall Street sessions recorded advances. Stocks of copper in L.M.E. official warehouses advanced by 225 tons to 16,807 tons, this change coming as something of a surprise to the market, which had rather expected a further reduction. The week opened, too, with news of an advance of 25 points in the custom smelters quotation to 24¼ cents and on Thursday this was followed by a rise in the Belgian price of ½ franc to fcs. 25·75. On the same day it became known that Anaconda had decided to reduce output at one of their North American properties by about 10 per cent. Business is believed to have been quiet throughout the week both at home and on the Continent, but in the United States it was reported that the custom smelters were experiencing a fairly good demand. Tin seems to be somewhat in the doldrums and support buying was seen at the floor level of £730. The Tin Council are believed now to be holding a very large tonnage of the metal. The turnover in copper futures on the New York Commodity Exchange was again heavy, and it seems fairly evident that the speculative boom is by no means over yet. Just how and when it will end is not easy to determine, but there are certain dangers inherent in the situation. The price has now been forced up to a very high level, and it can hardly be doubted that developments on Comex Bar were largely responsible for the further increase in the custom smelters' quotation.

The Copper Institute has issued the usual monthly copper figures in respect of April, which are shown as follows, in short tons of 2,000 lb. It will be noted that sizeable reductions occurred in every item both inside and outside the United States with the exception of refined deliveries in America. Outside the U.S.A., production of crude copper was 130,100 tons, which was nearly 28,000 tons down on March, while the output of refined, at 106,600 tons, showed a drop of 22,500 tons. Deliveries to consumers also registered a fall of fully 22,000 tons at 128,900 tons. Inside the United States, production of crude copper declined by only 1,600 tons to 97,400 tons, while the output of refined, at 120,500 tons, was about 9,600 tons below March. Deliveries of refined copper to consumers, however, advanced by 2,700 tons to 81,400 tons. From the above it would appear that the cuts in mine production are at last showing up, this being very apparent outside the United States. Deliveries were also lower, but not to such extent as the drop in output. The copper market in London, now displaying a very steady tone, reflects this improvement in the statistical situation.

Trading on the futures market in Whittingon Avenue last week amounted to a turnover of some 5,600 tons, the main feature being the extension of the contango to £3. Both cash and three months closed below the best but, nevertheless, a gain of 15s. was registered in cash and of 25s. in the three months' position, which stood at £180 5s. 0d. and £183 5s. 0d. respectively. On the whole, business on the Metal Exchange was dull. The turnover in tin was 850 tons, the market closing without change at £730 10s. 0d. cash and £733 10s. 0d. three months. Lead lost ground to the tune of 25s. for May and 15s. three months on a turnover of 4,775 tons, the contango widening to £1. Zinc was firm at the end of the week and, after a turnover of 5,375 tons, registered a gain of 7s. 6d. in both May and August.

New York

Copper sales showed some improvement in the past week. Custom smelters raised their prices one-quarter cent per lb., aided by a brisk demand from fabricators, and latterly reported that sales continued active at the new level. Leading copper producers said that they were selling copper a bit more actively to fabricators, but did not know whether it represented any upturn in fabricators' business or just the need of replenishing inordinately low stocks. Fabricator sources said their business was somewhat improved, aided by the usual seasonal betterment in construction. Traders said an encouraging factor in the custom smelter sales picture was the continued good demand at the higher price level. Thus far, trade sources said, this contrasted with the buying slump seen after similar price boosts earlier this year, when prices had to revert back to their former level.

Zinc producers said they sold Prime Western zinc a little more actively in the week, aided by better demand from galvanizers. Special high grade was generally quiet. Lead demand was spotty. Tin was generally steady and quiet, with little consumer interest.

Birmingham

Little change has taken place in Midland metal-using industries during the week. A period of steady production, free from labour disputes, is needed to restore confidence after the difficulties caused by the trouble in the motor trade of the last few weeks. In most other industries there has been some slowing down of activity. Forward buying is conspicuous by its absence, the general procedure being to place small orders for early delivery. The building trade is still quiet, and there is a shortage of business amongst makers of builders' brass and iron foundry products. Less buying is reported in the domestic holloware trade.

Foundrymen who produce castings for the motor trade are hoping to become busy again, but substantial business has been lost in the last few weeks. General engineers are busy and there is a good demand for heavy castings. Less work is likely to accrue for structural engineers during the second half of the year, as new business is being given out cautiously. Demand for heavy plates is sustained, and very little business is being placed abroad for this class of steel. In the re-rolling mills, short time was introduced some months ago owing to lack of business, and the position has not improved. Stocks of semi-finished steel are heavy at most works.

South Africa

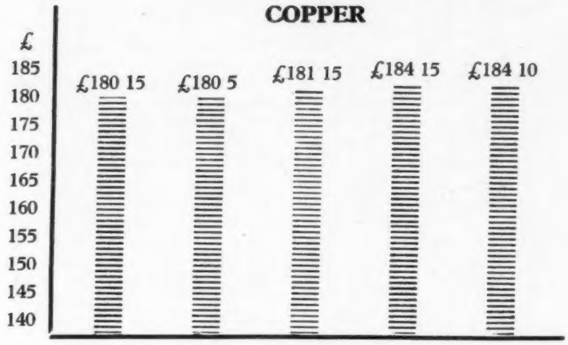
Applications for increased customs duties on a number of commodities are referred to in a recent issue of the Union of South Africa Government Gazette. It is stated that the Board of Trade and Industries of the South African Government have received representations regarding the Union's customs tariff on such items as brass, bronze, copper and copper alloys (including gilding metals and nickel silvers) in plain or perforated sheets, plate, strip, circles and foils, from free of duty (10 per cent in respect of foils) to 17½ per cent *ad valorem* plus a suspended duty of 10 per cent *ad valorem.*

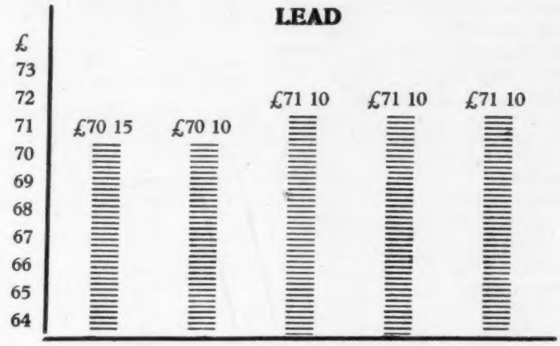
Where United Kingdom trade organizations are thought to be interested in these applications for such increased customs duties they are being informed, and it is suggested that any U.K. firm desiring to make representations to the Union Board of Trade and Industries, and belonging to a trade organization, should get in touch with that body in the first instance.

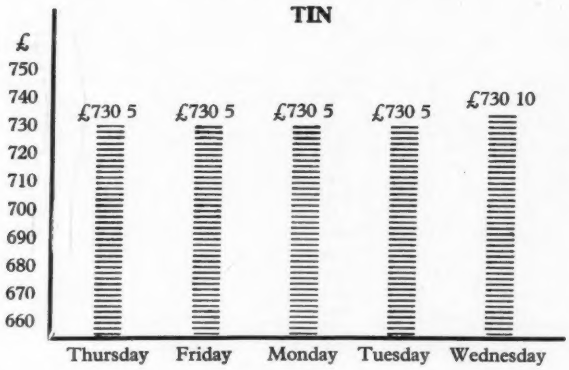
Enquiries from firms wishing to make independent representations, or desiring information on any other point relating to the above, should be addressed to the Commercial Relations and Exports Department, Board of Trade, Horse Guards Avenue, London. S.W.1, quoting reference C.R.E./6061/58.

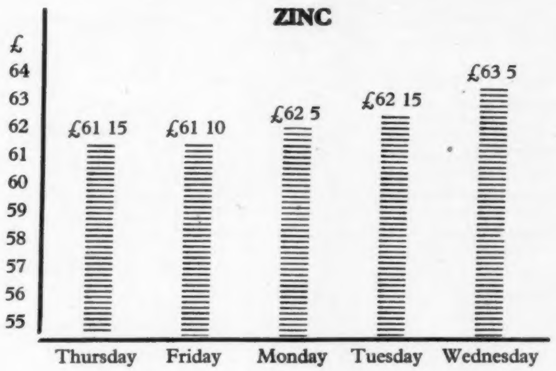
METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 29 May 1958 to Wednesday 4 June 1958









OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton		Canada c/lb ≏ £/ton		France fr/kg ≏ £/ton		Italy lire/kg ≏ £/ton		Switzerland fr/kg ≏ £/ton		United States c/lb ≏ £/ton	
Aluminium			22.50	185 17 6	210	182 15	375	217 10			26.10	208 17 6
Antimony 99.0					195	169 12 6	430	249 10			29.00	232 0
Cadmium					1,400	1,218 0					155.00	1,240 0
Copper												
Crude												
Wire bars 99.9							370	214 12 6				
Electrolytic	25.75	188 5	24.25	200 7 6	230	200 2 6			2.30	192 7 6	25.00	200 0
Lead			11.00	90 17 6	110	95 15	178	103 5	.93	77 15	11.50	92 0
Magnesium												
Nickel			71.50	590 10	1,205	1,048 7 6	1,330	771 10	7.80	652 5	74.00	592 0
Tin	102.25	747 10			915	796 0	1,400	812 0	8.60	719 2 6	94.37	755 0
Zinc												
Prime western			10.00	82 12 6							10.00	80 0
High grade 99.95			10.60	87 10 0								
High grade 99.99			11.00	90 5								
Thermic					107.12	93 2 6						
Electrolytic					115.12	100 2 6	153	88 15	.82	68 10	11.25	90 0

NON-FERROUS METAL PRICES

(All prices quoted are those available at 12 noon 4/6/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		10	0
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite	per unit		—	
Copper H.C. Electro.	ton	184	10	0
Fire Refined 99·70%	„	183	0	0
Fire Refined 99·50%	„	182	0	0
Copper Sulphate	„	66	0	0
Germanium	grm.		—	
Gold	oz.	12	9	4
Indium	„		10	0
Iridium	„	26	0	0
Lanthanum	grm.		15	0
Lead English	ton	71	10	0
Magnesium Ingots	lb.		2	5½
Notched Bar	„		2	10½
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	300	0	0
Mercury	flask	76	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„	7	10	0
Platinum	„	25	0	0
Rhodium	„	40	0	0
Ruthenium	„	16	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	3⅞
Tellurium	lb.		15	0
Tin	ton	730	10	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	63	5	0
Dust 95/97%	„	104	0	0
Dust 98/99%	„	110	0	0
Granulated 99+%	„	88	5	0
Granulated 99·99+%	„	101	2	6

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†Aluminium Alloy (Secondary)				
B.S. 1490 L.M.1	ton	151	0	0
B.S. 1490 L.M.2	„	158	0	0
B.S. 1490 L.M.4	„	179	0	0
B.S. 1490 L.M.6	„	195	0	0
†Average selling prices for April				
***Aluminium Bronze**				
BSS 1400 AB.1	ton	200	0	0
BSS 1400 AB.2	„	217	0	0
***Brass**				
BSS 1400-B3 65/35	„	129	0	0
BSS 249	„		—	
BSS 1400-B6 85/15	„		—	
***Gunmetal**				
R.C.H. 3/4% ton	ton		—	
(85/5/5/5)	„	152	0	0
(86/7/5/2)	„	163	0	0
(88/10/2/1)	„	211	0	0
(88/10/2/½)	„	221	0	0
Manganese Bronze				
BSS 1400 HTB1	„	168	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
***Phosphor Bronze**				
2B8 guaranteed A.I.D. released	„	240	0	0
Phosphor Copper				
10%	„	212	0	0
15%	„	220	0	0

**Average prices for the last week-end.*

		£	s.	d.
Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	349	0	0
Grade D Plumbers	„	283	0	0
Grade M	„	414	6	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9 „	„		—	
Zinc Alloys				
Mazak III	ton	94	7	6
Mazak V	„	98	7	6
Kayem	„	104	7	6
Kayem II	„	110	7	6
Sodium-Zinc	lb.		2	5

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium		£	s.	d.
Sheet 10 S.W.G.	lb.		2	8
Sheet 18 S.W.G.	„		2	10
Sheet 24 S.W.G.	„		3	1
Strip 10 S.W.G.	„		2	8
Strip 18 S.W.G.	„		2	9
Strip 24 S.W.G.	„		2	10½
Circles 22 S.W.G.	„		3	2
Circles 18 S.W.G.	„		3	1
Circles 12 S.W.G.	„		3	0
Plate as rolled	„		2	7½
Sections	„		3	1½
Wire 10 S.W.G.	„		2	11
Tubes 1 in. o.d. 16 S.W.G.	„		4	0

		£	s.	d.
Aluminium Alloys				
BS1470. HS10W.	lb.			
Sheet 10 S.W.G.	„		3	0½
Sheet 18 S.W.G.	„		3	3
Sheet 24 S.W.G.	„		3	10½
Strip 10 S.W.G.	„		3	0½
Strip 18 S.W.G.	„		3	2
Strip 24 S.W.G.	„		3	10
BS1477 HP30M.				
Plate as rolled	„		2	10½
BS1470. HC15WP.				
Sheet 10 S.W.G.	lb.		3	6½
Sheet 18 S.W.G.	„		4	0½
Sheet 24 S.W.G.	„		4	10½
Strip 10 S.W.G.	„		3	9½
Strip 18 S.W.G.	„		4	0½
Strip 24 S.W.G.	„		4	8
BS1477. HPC15WP.				
Plate heat treated	„		3	5½
BS1475. HG10W.				
Wire 10 S.W.G.	„		3	9½
BS1471. HT10WP.				
Tubes 1 in. o.d. 16 S.W.G.	„		4	11
BS1476. HE10WP.				
Sections	„		3	1
Beryllium Copper				
Strip	„	1	4	11
Rod	„	1	1	6
Wire	„	1	4	9
Brass Tubes	„		1	5⅜
Brazed Tubes	„		—	
Drawn Strip Sections	„		—	
Sheet	ton		—	
Strip	„		—	
Extruded Bar	lb.		1	8¼
Extruded Bar (Pure Metal Basis)	„		—	
Condenser Plate (Yellow Metal)	ton	147	0	0
Condenser Plate (Naval Brass)	„	158	0	0
Wire	lb.		2	3⅜
Copper Tubes	lb.		1	8⅞
Sheet	ton	208	15	0
Strip	„	208	15	0
Plain Plates	„		—	
Locomotive Rods	„		—	
H.C. Wire	„	228	15	0
Cupro Nickel				
Tubes 70/30	lb.		3	2⅜
Lead Pipes (London)	ton	112	0	0
Sheets (London)	„	109	15	0
Tellurium Lead	„	£6 extra		
Nickel Silver				
Sheet and Strip 7%	„		3	3
Wire 10%	„		3	9¾
Phosphor Bronze				
Wire	„		3	6¾

Titanium (10,000 lb. lots)			
Billet 11″-4″	lb.	69/-	60/-
Wire ·315″-·036″	„	101/-	201/-
Sheet (4′/8′ × 2′) ·160″-·010″	„	100/-	158/-
Strip ·048″-·003″	„	100/-	350/-
Tube Representative gauge	„	320/-	
Extrusions	„	137/-	

		£	s.	d.
Zinc Sheets, English destinations	ton	96	0	0
Strip	„		nom.	

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 3/6/58.

	£
Aluminium	
New Cuttings	143
Old Rolled	120
Segregated Turnings	90
Brass	
Cuttings	115
Rod Ends	113
Heavy Yellow	98
Light	93
Rolled	107
Collected Scrap	95
Turnings	107
Copper	
Wire	160
Firebox, cut up	160
Heavy	152
Light	147
Cuttings	160
Turnings	145
Braziery	125
Gunmetal	
Gear Wheels	155
Admiralty	155
Commercial	129
Turnings	124
Lead	
Scrap	63
Nickel	
Cuttings	—
Anodes	476
Phosphor Bronze	
Scrap	129
Turnings	124
Zinc	
Remelted	53
Cuttings	40
Old Zinc	30

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£156.12.6)	180
Heavy copper	(£152.5.0)	175
Light copper	(£130.10.0)	150
Heavy brass	(£100.0.0)	115
Light brass	(£69.12.6)	80
Soft lead scrap	(£57.10.0)	66
Zinc scrap	(£36.10.0)	42
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£193.2.6)	222
Heavy copper	(£193.2.6)	222
Light brass	(£139.5.0)	160
Zinc castings	(£65.5.0)	75
Tin	(£565.10.0)	650
Aluminium pans (98½ per cent)	(£117.10.0)	135
Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£191.10.0)	330
Aluminium copper alloy	(£101.10.0)	175
Lead, soft, first quality	(£84.2.6)	145
Lead, battery plates	(£49.7.6)	85
Copper, first grade	(£174.0.0)	300
Copper, second grade	(£162.10.0)	280
Bronze, first quality machinery	(£177.0.0)	305
Bronze, commercial gunmetal	(£148.0.0)	255
Brass, heavy	(£124.15.0)	215
Brass, light	(£113.2.6)	195
Brass, bar turnings	(£121.17.6	210
New zinc sheet clippings	(£55.2.6)	95
Old zinc	(£40.12.6)	70

Financial News

Morgan Crucible Co. Ltd.

This company is again repeating its dividend at 10 per cent, with a final payment of 6½ per cent, for the year ended March 30, 1958. It is understood that this final dividend is payable on an additional 100,740 "A" Ordinary £1 shares issued in January last against the acquisition of a further hold in the Ship Carbon Co. of Great Britain. Group profits are shown at £1,901,479 (£2,037,826); net profit, after taxation, was £948,904 (£1,034,827).

H. J. Enthoven and Sons

Consolidated loss 1957 £156,334 (profit £29,281) and no dividend on Ordinary (same). Fixed assets £438,642 (£423,941), investments £77,640 (£348,505), and net current assets £600,004 (£627,040). Bank overdraft of previous year, £109,800, eliminated. Commitments £40,000.

The Mint, Birmingham

Net profit, including transfer of £16,492 (£23,848) from metal stock reserve, year ended March 31, 1958, £19,514 (£24,786). Surplus tax £284 (£941) and non-recurring items £5,159. To contingencies reserve £10,000 (£15,000), staff pension reserve £5,000. Ordinary dividend 7½ per cent plus bonus 2½ per cent (same), forward £24,002.

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

Charles Ellis (Non-Ferrous) Limited (601384), 3 The Broadway, S.W.20. Registered March 26, 1958. To carry on business of merchants of and dealers in waste and scrap materials, etc. Nominal capital, £100 in £1 shares. Directors: Reginald C. Ellis and Ruby D. Honnor.

Darlaston Die Casting Co. Limited (601401), Horton Street, Darlaston. Registered March 27, 1958. To take over business of "Darlaston Die Casting Co." carried on at Darlaston; and to carry on business of producers of diecastings; mechanical engineers, etc. Nominal capital, £1,000 in £1 shares. Directors: Frank Dangerfield, Ernest R. Lowe and Edward S. Yates.

H. and C. R. Bradbury Ltd. (601417), Silvergate Works, Brown Lane, Leeds, 12. Registered March 27, 1958. To carry on business of general smiths, metal workers, etc. Nominal capital, £3,000 in £1 shares. Directors: Cyril R. Bradbury, Jack Bradbury, Edna Bradbury and Lilian Bradbury.

Trade Publications

Safety Equipment.—J. and R. Fleming Ltd., 146 Clerkenwell Road, London, E.C.1.

In a twelve-page booklet distributed by this company, details and illustrations are given of a wide range of safety equipment manufactured by them. The items described include spectacle type goggles, welding goggles and shields, plastic eye and face shields. Some notes on "Armorglas," the Fleming toughened lenses, are also included, as well as a reminder that the same company can supply respirators, protective clothing, readers and magnifiers, impregnated diamond tools, and abrasive powders.

Organic Chemicals.—L. Light and Co. Ltd., Poyle Trading Estate, Colnbrook, Bucks.

After a year of building activities, re-organization and additional premises, this firm has now produced a new and larger catalogue in which is listed the full range of organic research chemicals and auxiliary materials which they now offer. The catalogue covers some 78 pages and is divided into sections dealing, first, with a general list of organic chemicals, then alkaloids, steroids, spectrographically-standardized substances, precious metal catalysts, ion exchange materials, non-ionic surface active agents, sequestering agents and "Celite" filter aids, and, finally, photosensitizing dyes.

Variable Speed Gears. — Carter Gears Ltd., Thornbury Road, Bradford, 3.

An eight-page folder is intended as a guide to the entire range of "A" and "F" type Carter gears, and includes dimension and rating tables, accompanied by a number of illustrations.

Electrical Units.—The English Electric Company Ltd., Stafford.

Five new publications have been issued by this company, dealing with their fuse-gear, B.S.D. ventilated motors, 3 h.p. motor controllers, and ½ h.p. megamps.

Epikote Resins Tooling Applications.—Shell Chemical Co. Ltd., Marlborough House, 15-17 Gt. Marlborough Street, London, W.1.

This technical bulletin sets out details and required mechanical properties of plastics tools, describes auxiliary and work tools, and includes a number of diagrams.

Electric Furnaces.—Royce Electric Furnaces Ltd., Sir Richard's Bridge, Walton-on-Thames, Surrey.

In this twelve-page booklet a number of representative types of electric furnaces in the range manufactured by this company are described and illustrated. Those dealt with include bell-type or "top-hat" furnaces, general box type, a molybdenum furnace, tube furnace, tubular vacuum furnace, hump-back conveyor furnace, continuous conveyor furnace, continuous rotary drum furnace, tube heating furnaces for maintaining special metals in liquid form, a twin chamber atmosphere muffle furnace for heating alloy billets in a special protective atmosphere, a forced air circulation oven, and a continuous pusher-type high temperature kiln. Each description is accompanied by a suitable photograph of the furnace.

THE STOCK EXCHANGE

Support For Industrials Improved Slightly

ISSUED CAPITAL ●	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 3 JUNE	+RISE —FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	20/6		10	10	9 15 0	20/6	17/9	28/3	18/–
400,000	2/–	Anti-Attrition Metal	1/6		4	8½	5 6 9	1/6	1/3	2/6	1/6
33,639,483	Stk. (£1)	Associated Electrical Industries ...	48/–	—3d.	15	15	6 5 0	51/–	47/–	72/3	47/9
1,590,000	1	Birfield Industries	46/3	—1/3	15	15	6 9 9	53/9	46/3	70/–	48/9
3,196,667	1	Birmid Industries	65/6	+2/6	17½	17½	5 6 9	65/6	56/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	28/6		10	8	7 0 3	28/6	23/9	33/–	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/4½		5	5	6 10 0	15/7½	14/7½	16/–	15/–
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/7½		6	6	7 4 3	17/–	16/6	19/–	16/6
500,000	1	Bolton (Thos.) & Sons	26/3		12½	12½	9 10 6	28/9	26/3	30/3	28/9
300,000	1	Ditto Pref. 5%	15/3		5	5	6 11 3	16/–	15/3	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/3		7	7	7 5 6	19/3	19/–	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	41/6	+3/3	12	12	5 15 9	46/6	37/–	72/–	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/–		6	6	6 6 3	19/3	18/4½	21/6	18/–
15,000,000	Stk. (£1)	British Insulated Callender's Cables	43/6	+3d.	12½	12½	5 15 0	44/3	38/9	55/–	40/–
17,047,166	Stk (£1)	British Oxygen Co. Ltd., Ord. ...	35/–	+3d.	10	10	5 14 3	35/3	29/–	39/–	29/6
600,000	Stk. (5/–)	Canning (W.) & Co.	19/9		25 + *2½C	25	6 6 6	21/–	19/9	24/6	19/3
60,484	1/–	Carr (Chas.)	2/–		25	25	X 8 15 0	2/3	2/–	3/6	2/1½
150,000	2/–	Case (Alfred) & Co. Ltd.	4/3		25	25	11 16 3	4/9	4/1½	4/6	4/–
555,000	1	Clifford (Chas.) Ltd.	17/–		10	10	11 15 3	17/–	16/–	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/10½		6	6	7 11 3	—		17/6	16/–
250,000	2/–	Coley Metals	2/10½	—4½d.	20	25	13 18 3	4/6	2/10½	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	42/6	—1/9	18¾	22½	8 16 6	51/6	42/6	92/6	49/–
1,136,233	1	Davy & United	50/–		15	12½	6 0 0	50/–	45/9	60/6	42/6
2,750,000	5/–	Delta Metal	18/10½	+4½d.	30	*17½	7 19 0	21/4½	17/7½	28/6	19/–
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	31/6	—6d.	12½	15B	7 18 9	33/–	24/–	38/6	25/–
750,000	1	Ev[illegible] & Co. [illegible]	26/–xcap		15	15	7 2 9	28/–	26/–	52/9	42/–
18,000,000	Stk. (£1)	General Electric Co.	30/–	—9d.	12½	14	Y7 13 3	38/7½	29/6	59/–	38/–
1,250,000	Stk. (10/–)	General Refractories Ltd.	32/3	+3d.	20	17½	6 4 0	33/9	27/3	37/–	26/9
401,240	1	Gibbons (Dudley) Ltd.	66/–		15	15	4 11 0	66/3	64/–	71/–	53/–
750,000	5/–	Glacier Metal Co. Ltd.	6/6	+6d.	11½	11½	8 17 0	6/6	5/7½	8/1½	5/10½
1,750,000	5/–	Glynwed Tubes	13/4½		20	20	7 9 6	13/6	12/10½	18/–	12/6
5,421,049	10/–	Goodlass Wall & Lead Industries ...	23/6	+3d.	13‖	18Z	5 10 9	23/6	19/3	37/3	28/9
342,195	1	Greenwood & Batley	46/9		17½	17½	7 9 9	46/10½	45/–	50/–	46/–
396,000	5/–	Harrison (B'ham) Ord.	12/1½	+3d.	*15	*15	6 3 9	12/4½	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	19/–		7	7	7 7 3	19/–	18/9	22/3	18/7½
1,075,167	5/	Heenan Group	7/3		10	20‡	6 18 0	7/7½	6/9	10/4½	6/9
142,045,750	Stk. (£1)	Imperial Chemical Industries ...	44/3	+3d.	12Z	10	5 8 6	44/10½	36/6	46/6	36/3
33,708,769	Stk. (£1)	Ditto Cum. Pref. 5%	16/4½		5	5	6 2 3	17/1½	16/–	18/6	15/6
14,584,025	**	International Nickel	140¾xd	+1½	$3.75	$3.75	4 15 3	144½	134	222	130
433,003	5/–	Jenks (E. P.), Ltd.	8/3	+6d.	27½ϕ	27½	8 6 9	8/3	6/9	18/10½	15/1½
300,030	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3		5	5	6 3 0	16/3	15/–	17/–	14/6
3,987,435	1	Ditto Ord.	44/–		10	9	4 11 0	44/6	37/6	58/9	40/–
600,030	10/–	Keith, Blackman	16/3		15	15	9 4 6	16/3	15/–	21/9	15/–
160,030	4/–	London Aluminium	3/6	+6d.	10	10	11 8 6	4/3	3/–	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord. ...	43/6	+6d.	12½	12½	5 15 0	43/9	39/9	54/6	41/–
400,030	1	Ditto Pref.	22/9	+3d.	7½	7½	6 11 9	22/9	22/3	25/3	21/9
765,012	1	McKechnie Brothers Ord.	32/6	+6d.	15	15	9 4 6	35/–	32/–	48/9	37/6
1,530,024	1	Ditto A Ord.	31/3	+6d.	15	15	9 12 0	32/6	30/–	47/6	36/–
1,108,263	5/–	Manganese Bronze & Brass	9/6		20	27½‡	10 10 6	10/6	9/–	21/10½	7/6
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–		7½	7½	7 10 0	6/3	5/9	6/6	5/–
13,098,855	Stk. (£1)	Metal Box	49/3	—9d.	20‡	15M	4 1 3	50/–	41/9	59/–	40/3
415,760	Stk. (2/–)	Metal Traders	7/–		50	50	14 5 9	7/–	6/3	8/–	6/3
160,000	1	Mint (The) Birmingham	20/–		10	10	10 0 0	22/9	20/–	25/–	21/6
80,000	5	Ditto Pref. 6%	81/6		6	6	7 7 6	83/6	81/6	90/6	83/6
3,064,930	Stk. (£1)	Morgan Crucible A	38/6		10	11	5 4 0	40/–	34/–	54/–	35/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/–		5½	5½	6 9 6	17/3	17/–	19/3	16/–
2,200,000	Stk. (£1)	Murex	55/–		20	20	7 5 6	57/6	53/3	79/9	57/–
468,000	5/–	Ratcliffs (Great Bridge)	7/3		10	10	6 18 0	7/3	6/10½	8/–	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	25/6		20	27½D	7 16 9	27/–	25/6	41/–	24/9
1,365,000	Stk. (5/–)	Serck	12/4½	—1½d.	17½Z	15	4 14 3	12/7½	11/-	18/10½	11/6
600,400	Stk. (£1)	Stone (J.) & Co. (Holdings)	43/9		16	16	7 6 6	—		57/6	43/9
600,000	1	Ditto Cum. Pref. 6½%	20/–		6½	6½	6 10 0	20/9	20/–	21/9	18/9
14,494,862	Stk. (£1)	Tube Investments Ord.	54/9	+9d.	15	15	5 9 6	54/9	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	30/–	—1½d.	10	10	6 13 3	32/6	29/4½	46/–	29/–
750,000	Stk. (£1)	Ditto Pref. 5%	15/–		5	5	6 13 3	15/6	14/9	18/–	14/–
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/3		*5	*5	7 4 9A	23/–	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	74/9	+1/–	20	15	5 7 0	76/3	70/9	83/–	64/–
2,666,034	Stk. (£1)	Westinghouse Brake	39/–	+3d.	10	18P	5 2 6	39/–	32/6	85/–	29/1½
225,000	2/–	Wolverhampton Die-Casting ...	7/4½		25	40	6 15 6	8/–	7/1½	10/1½	7/–
591,000	5/–	Wolverhampton Metal	17/3		27½	27½	7 19 6	17/7½	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	3/6		20	17½E	14 5 9	3/9¾	3/3	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	11/6		6	6	10 8 9	—		12/6	11/3
150,000	1/–	Zinc Alloy Rust Proof	2/10½		40D	33½	9 5 6	3/1½	2/7½	5/–	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting **Shares of no Par Value. ‡ and 100% Capitalized Issue. ●The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. M and 10% capitalized issue. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/– per share for £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. ϕ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.